POWER PLANT ENGINEERING

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The Plant of the Field Museum of Natural History

ENGINEERING FEATURES OF THE POWER PLANT FOR THE LARGEST MARBLE BUILDING IN THE WORLD

WITHIN a few hundred feet of the water's edge on the shore of Lake Michigan in Grant Park, Chicago, there stands an immense white marble edifice which cannot but command the wonder and admiration of all those passing by. Its exquisite beauty and dignity at once convey the impression that here is no ordinary building and this impression, to say the least, is entirely correct.

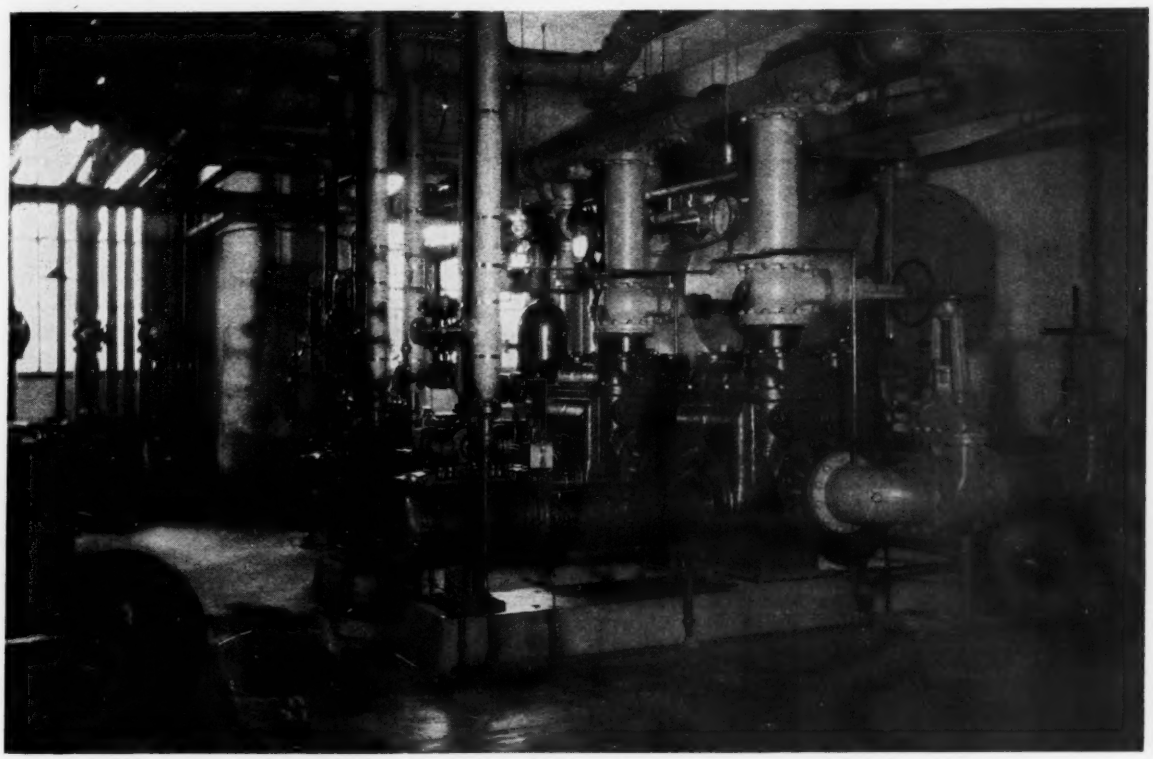


FIG. 1. VIEW IN PUMP ROOM SHOWING VACUUM AND BOILER FEED PUMPS

Its perfect symmetry and classical lines bespeak of an architectural achievement of the highest order.

This incomparable structure is the new home of the Field Museum of Natural History. Within its walls are gathered and arranged in systematic order, priceless treasures from the remote corners of the earth. Here may be found nature's pages on which is written in time-defying language the history of the earth's development —the record of the rocks. Here in silent dignity repose the bones of the Dinosaur who wallowed in the Mesozoic swamps some fifty million years ago. Here are grouped specimens of the world's minerals, its woods, its plant life and its animal life; classified and arranged with scientific precision—it is a veritable wonderland.

The Field Museum of Natural History was established in 1893 at the close of the World's Columbian Exposition. The founding of a scientific institution of this character in Chicago was made possible by a gift of $1,000,000 by Marshall Field (whose name the institution bears) and who on his death in 1906 bequeathed the institution a further sum of $8,000,000, of which $4,000,000 was designated to be used for the erection of a building and $4,000,000 for endowment.

The building now occupied by the Museum is the largest marble building ever built. It is 350 ft. wide and 700 ft long. There are four floors, two of which are devoted to exhibition purposes, while the ground and third floors are used as working space for the scientific and maintenance staff. The main central hall, dedicated to Stanley Field, president of the institution, rises to the entire height of the building and is 324 ft. in length. The rest of the structure is divided into floors.

The exterior, of Georgia white marble, is about 80 ft. high and is treated in a monumental manner based on

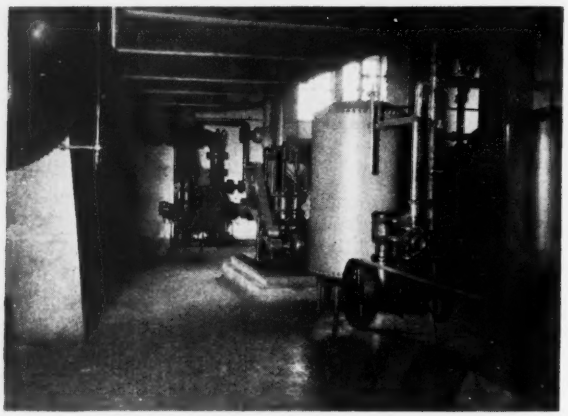


FIG. 3. VIEW IN PUMP ROOM SHOWING AIR COMPRESSORS AND FIRE PUMP

Greek architecture of the Ionic order. The principal fronts are divided into a large pedimented central pavilion with two long wings terminated by a smaller pavilion at each end. One of the principal features of the structure is a terrace about 40 ft. wide, which completely surrounds the building and rises about 6 ft. above the adjacent territory.

In this structure, the architects, Graham, Anderson, Probst & White have given to the city of Chicago and the country a masterpiece of monumental building, having distinction and dignity commensurate with its purpose and origin.

Power and Heating Requirements

Judging from the foregoing introduction, it must be obvious to the reader that the heating and power requirements for a building of this type and size are by no means inconsiderable, and that the power plant must possess features of engineering interest. The principal feature, of course, is the heating system, which comprises approximately 140,000 sq. ft. of direct radiation, and is served by the power plant to be described in this article.

No attempt is made to generate any of the electrical energy used in the Museum. This is conveniently obtained from the lines of the Commonwealth Edison Co., who have installed a transformer sub-station in the basement of the building.

The electrical load is mostly a lighting load. Although practically all parts of the building receive illumination during the daytime, a considerable amount of electrical energy is used for lighting the building in the late afternoon hours of the winter months. In January of this year, for instance, the amount of electricity consumed was 14,000 kw.-hr., this figure including the motor load. In addition to the power required for running the elevators, ventilating fans, pumps, etc., power is required for numerous other purposes in the laboratories and workrooms.

The Power Plant

The power plant, located in the southwest quarter of the building, consists of two rooms, the boiler room and the pump room. The pump room is located in the basement or ground floor. While this floor is often referred to as the basement, it is actually at an elevation of 34 ft. above the lake level and about 3 ft. above grade. The boiler room is located adjacent to the pump room outside of the building proper with the floor level 26 ft. below the ground floor. It is therefore entirely underground. In planning the building, this arrangement was decided upon because of a number of reasons,

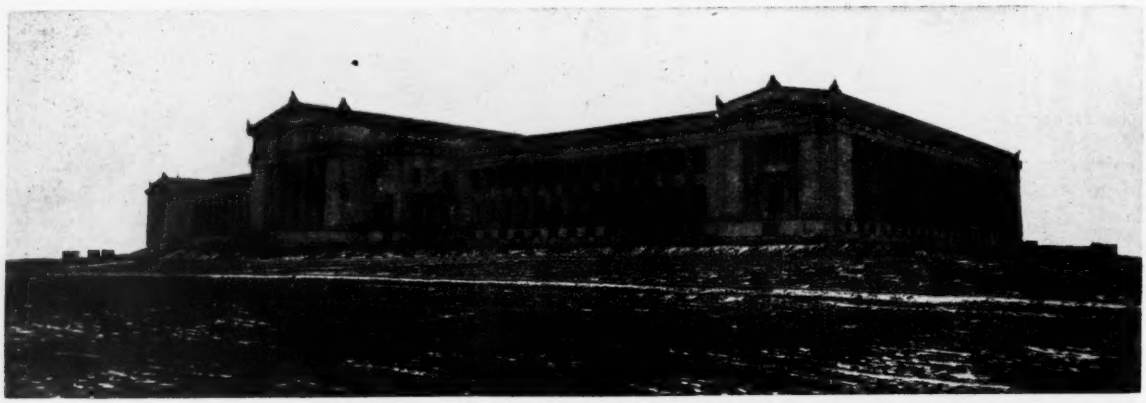


FIG. 2. THE FIELD MUSEUM OF NATURAL HISTORY

the most important of which probably is the element of safety. The Museum, because of the almost priceless treasure it contains, is forced to carry its own insurance. No insurance company could afford to undertake to insure the collections at any reasonable rate and as many of the exhibits are irreplaceable, it is imperative that the utmost precaution be taken to protect them from destruction by fire or otherwise. The building itself is as fireproof as modern engineering methods and human ingenuity can make it. In the boiler room, however, the possibility of explosion is an additional source of danger. A boiler explosion, howsoever small, is capable of doing great damage in a building of the type

under consideration, and by locating the boiler room underground, apart from the main building, the danger of damage from explosion is considerably diminished. A further advantage secured by locating the boiler room in the manner described is the practical elimination of coal dust, which, as will be evident, has no place in this institution.

Coal and Ash Handling Equipment

Coal is delivered to the boiler room in small cars through a tunnel extending from the boiler room to the tracks of the Illinois Central Railroad about two blocks away. This tunnel also serves to dispose of the ashes, as will be described later. From the tunnel-cars, coal is discharged by gravity into a track hopper and thence into a "Perkins" pivoted bucket conveyor by means of which it is elevated to the upper part of the boiler room. Here by means of a movable tripper, the coal is discharged either into the coal bunkers or into the receiving hopper of a screw conveyor. The bucket conveyor is driven by a 15-hp. electric motor located at the end of the upper run.

When coal is being delivered to the plant, the tripper or the bucket conveyor is set so as to discharge the coal into bunkers, where it is stored until needed. Coal for the stokers is delivered from the bottom of the coal bunkers through hand operated coal valves into the bucket conveyor and is discharged into the previously mentioned screw conveyor above the bunkers.

The screw conveyor is installed at right angles to the conveyor and delivers the coal to the hopper of a weigh larry. This larry travels the length of the boiler room and discharges into the individual stoker hoppers.

If, due to unforeseen conditions, coal could not be delivered through the tunnel it could be delivered by truck into the coal bunkers from the roadway above. The bunkers are also fitted with hand operated sliding doors through which coal may be shoveled into the stoker hoppers by hand.

All the coal handling apparatus with the exception of the Fairbanks scale used on the weighing larry, was manufactured by the Webster Mfg. Co.

Ash is removed from the ash pits through the ash cleanout doors and by means of a hoe is delivered into the suction hoppers of a Green Engineering Co. steam jet ash conveyor, which is installed along the fronts of the boiler below the floor as shown in Fig. 4. Ashes carried through this conveyor line are discharged into an ash hopper located at the side of the coal bunkers above the tunnel tracks. From the bottom of the ash hopper, the ashes drop into the tunnel cars by which they are removed from the plant. This system of ash removal is simple in operation, does not require much space and has proved economical insofar as maintenance is con-

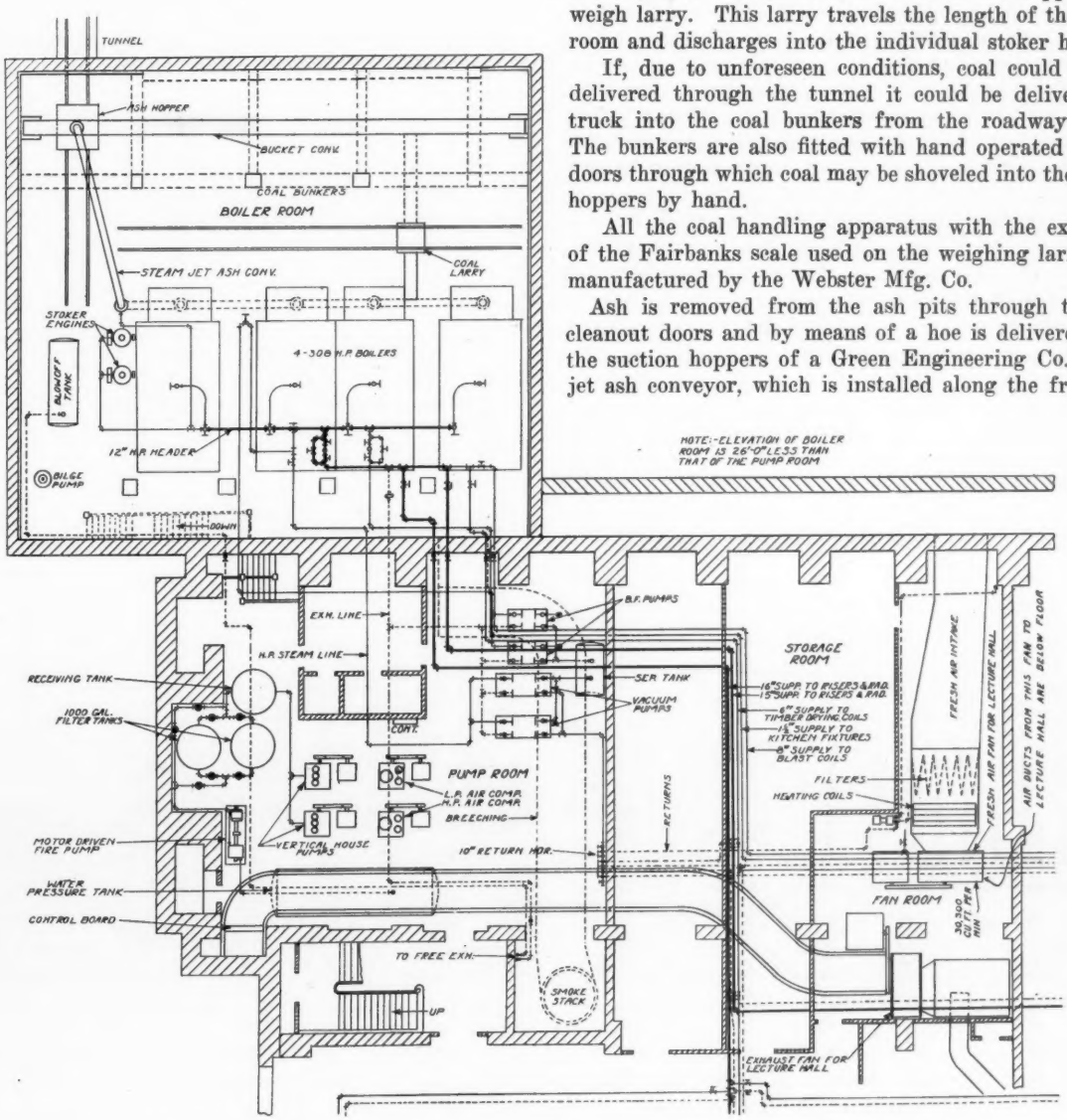


FIG. 4. PLAN SHOWING ARRANGEMENT OF EQUIPMENT IN BOILER AND PUMP ROOM

cerned. It is operated by steam at a pressure of from 75 to 100 lb. gage.

Steam Generation

Steam is generated at a pressure of from 75 to 100 lb. in four Kroeschell, water tube boilers rated at 308 hp. each. These boilers are of the Heine type, are horizontally baffled and each contain 176 3½-in. by 18-ft. tubes. The drum is 48 in. in diameter and approximately 20 ft. in length. The boilers are fitted with Crane stop and check valves and Crosby blowoff valves. For keeping the gas passages clean, each boiler is equipped with Bayer soot blowers. Green chain grate stokers provided with skids to prevent sagging of the grate are installed under each boiler. These stokers are all operated by eccentric rods from a line shaft extending across the boiler fronts and driven at one end by either of two Wach high-speed vertical reciprocating engines. The details of this installation may be seen in Fig. 4.

The furnaces which are approximately 7 ft. wide are provided with Sealflex arches. The products of combustion are removed by a 90 ft. steel stack, connected to the boilers by a steel breeching.

As shown in Fig. 4, a horizontal blowoff tank is located in a covered pit adjacent to the boilers. The boilers are blown down into this tank, from which the water is in turn removed by the small Yeomans motor-driven centrifugal bilge pump indicated on the drawing. This bilge pump is a small vertical unit and, as its name implies, is also used to drain the lower portion of the boiler room where the lower run of the bucket conveyor is located. An interesting feature, which may be mentioned in connection with the blowoff tank, is that it contains a pipe coil through which make-up water to the boilers is circulated before being delivered to the receiving tank in the pump room. With this arrangement, a portion of the heat, which would otherwise be wasted in the blowoff water, is recovered and returned to the heating system. It furthermore reduces the possible danger of damage due to expansion strains being set up in the equipment by the sudden entrance of cold water.

Boiler Room Piping

Steam is taken from the boilers through 6-in. boiler headers which connect into a 12-in. high pressure, main header located above the boilers, as shown in Fig. 7. This header is connected to the low pressure header which is also located above the boilers, through a 10 in. by 16 in. Kieley and Mueller pressure reducing valve. The latter serves to reduce the steam pressure from boiler pressure to that required in the heating mains. The reducing valve is fitted with a 6-in. bypass for use in case of emergency, as shown in Fig. 7. In addition to being supplied with live steam through the reducing valve, the low pressure header is also supplied with exhaust steam through a 6-in. line from the auxiliary apparatus in the pump room.

The main arteries through which steam is supplied to the heating system are the large 16 and 15-in. mains which are shown leading from the low pressure header in Fig. 7. The 16-in. line supplies the south half of the building and the 15 in. the north half. Two smaller mains, a 6-in. and an 8-in. supply steam to the theatre or lecture hall and the north door respectively.

High pressure steam for operating the pumps, stoker engines, ash conveyors, etc., is taken directly from the high pressure main as shown in the drawing. The 4-in. line supplying steam to the boiler feed pump, loops down to the floor so that the feed pumps in the pump room may be controlled from the boiler room.

Two 4-in. feed water headers are located above the boilers, one being supplied directly from the boiler feed

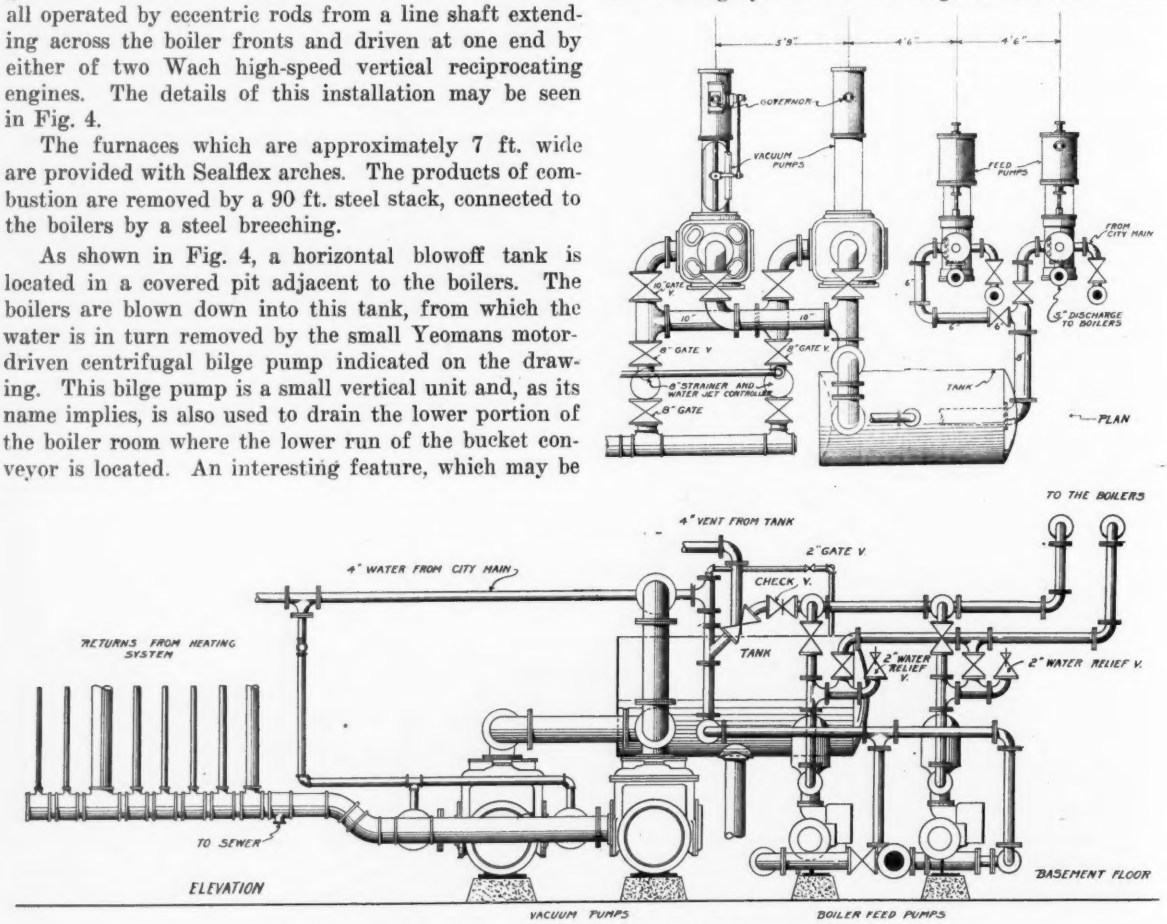


FIG. 5. DETAILS OF VACUUM AND BOILER FEED PUMP PIPING

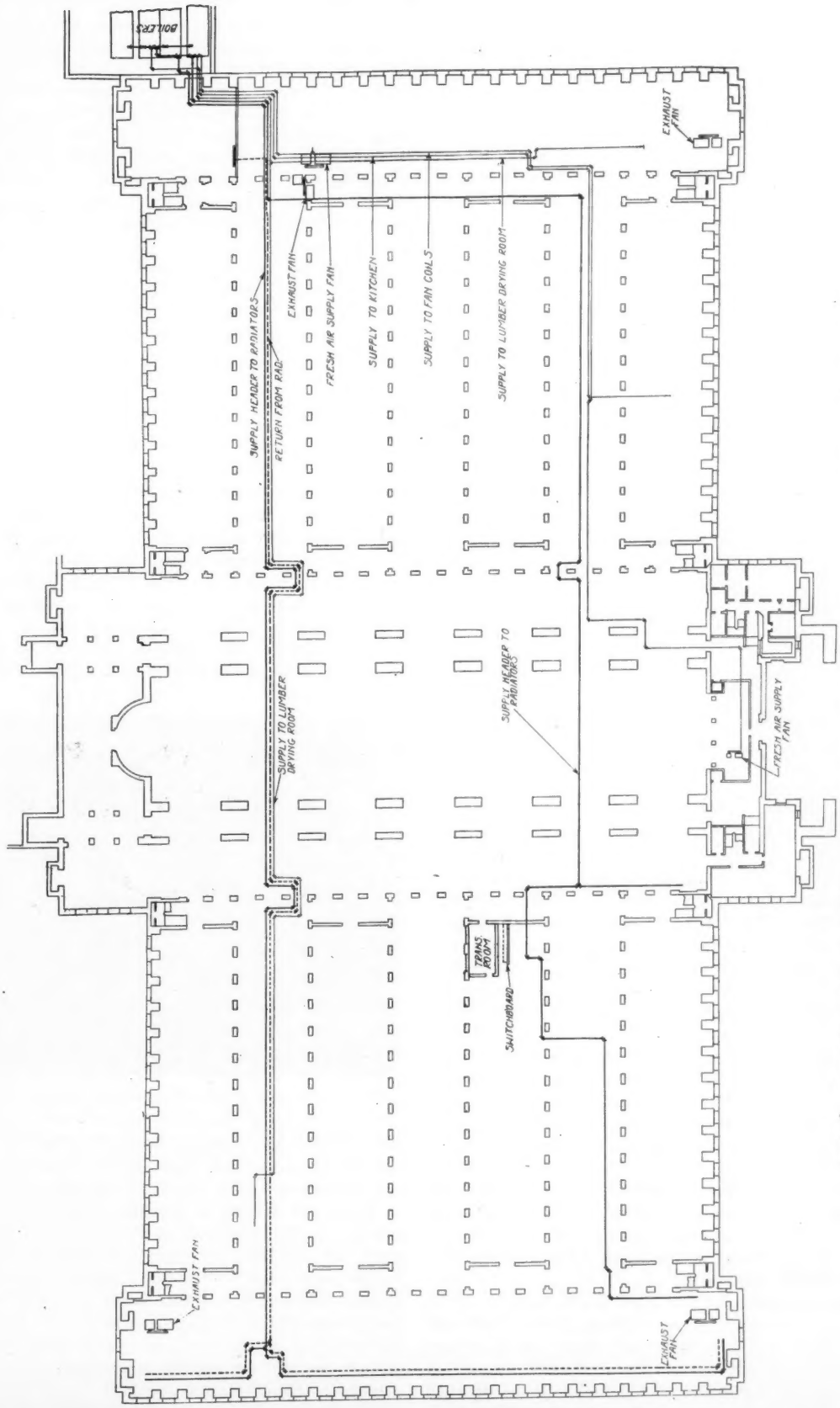


FIG. 6. GENERAL PLAN OF GROUND FLOOR OF MUSEUM SHOWING HEATING MAINS AND LOCATION OF FANS

pumps, while the other is supplied with cold water from the city mains. Branches from each of these headers connect into a single 2-in. boiler feed line to each boiler. The boilers can thus be fed from either line.

The Pump Room

The pump room, as stated previously, is located in the main building, 26 ft. above the boiler room floor, and is approximately 60 ft. long by 52 ft. wide. The arrangement of the equipment is as indicated on the plan, Fig. 4, while the piping details of the boiler feed and vacuum pumps are shown in Fig. 5.

Two 14 by 9 by 18-in. Prescott simplex boiler feed pumps are provided. These take suction from the receiving tank or from the city mains, as desired, and pump

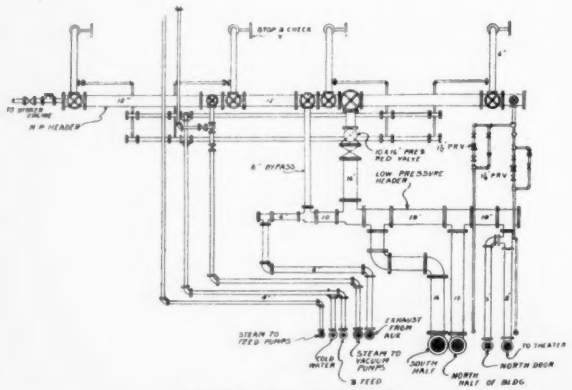


FIG. 7. BOILER PIPING

the water through an economizer into the boilers. The economizer under normal operating conditions effects an increase of approximately 12 deg. in the temperature of the water.

The two vacuum pumps for the heating system are located adjacent to the feed pump and are of the simplex type made by the American Steam Pump Co. These pumps are both 14 by 20 by 20 in. and operate on a steam pressure of from 75 to 100 lb. Suction is taken from the condensate manifold into which condensate from all parts of the heating system is returned. The water is discharged through a 10-in. line into the receiving tank, from which it is returned to the boilers as described in the previous paragraph. Make up water from the city mains is delivered into the top of the receiving tank through a 4-in. line as shown.

Both the boiler feed pump and vacuum pumps are automatically controlled by McAlear governors.

Compressed air for laboratory purposes is supplied by two 4¾ by 4¾-in. duplex, Blake-Knowles, air compressors, belt driven by 10-hp., 220-v., three-phase, 60-cycle Western Electric induction motors. Each compressor delivers air to its own receiving tank and the driving motors are automatically controlled by the air pressure in the tanks through the agency of Cutler-Hammer control apparatus.

Water for general house purposes is supplied from the city mains to either of two 1000-gal. Jewel filters and thence to the large receiving tank shown on the pump room plan. The filters are arranged with a bypass so that in case of necessity, city water may be supplied direct to the receiving tank. From the latter, water is drawn by two Gould's 5 by 8-in. triplex pumps, belt driven by 5 hp., 220-v., three-phase, 60-cycle Wagner motors, and pumped up to two large storage tanks located on the fourth floor which serve to maintain a constant pressure on the house service mains. The storage tanks each have a capacity of 2500 gal. and are fitted with float control switches for controlling the triplex pumps in the pump room. If the water level in the storage tanks falls below normal, the float switch comes into action and starts the house pumps, thus filling the tanks until the high water level is reached, when the pump is stopped.

In addition to the foregoing list of equipment, the pump room contains a Lea Equipment Co. three-stage centrifugal fire pump. This pump is rated to supply 1000 gal. of water per min. under a pressure of 125 lb. and is driven at 1120 r.p.m. by a 100-hp., 220-v., three-phase 60-cycle General Electric Co. induction Co. motor, equipped with Cutler-Hammer automatic control.

The Heating System

The heating system is a vacuum system throughout, steam being circulated below atmospheric pressure. Under ordinary weather conditions, a difference in pressure of one or two inches of water is maintained between the supply and return mains, the return-line pressure being kept constant at all times at 16 in. of vacuum. In severe cold weather the pressure in the supply headers may run as high as 5 or 6 in. of vacuum.

All heating of the building with the exception of certain rooms on the ground floor is by direct radiation.

FIG. 8. VIEW IN BOILER ROOM

American radiators equipped with Dunham thermostatic radiator traps and American Radiator Sylphon Leakless radiator valves are installed throughout the building.

Steam for heating is distributed by two large mains, one supplying the north half of the building and the other the south half, as shown in Fig. 6. The return mains, as a rule, are installed parallel to the supply mains. All mains are suspended from the ceiling on roller supports so as to prevent strain due to expansion being set up in the line. Movement due to expansion is compensated for by the provision of a number of expansion loops.

All radiators on the upper floors are supplied

through risers branching off from the main supply lines in the basement.

The lumber drying rooms, the printing shop and the shipping room, all of which are located in the basement, are heated by overhead coils. The shipping room, which is below the basement floor level, is provided with a motor-driven condensate pump for returning the condensate to the pump room. Simpson theatre and the north door are provided with similar condensate return pumps.

A feature in connection with the heating system that is of interest, is the fact that no humidifiers or other air conditioning equipment is installed. In a steam heated building of this size, one might be inclined to regard the installation of some sort of humidifying apparatus of paramount importance and under ordinary circumstances this view of the matter would be correct; the dryness of ordinary steam-heated air would certainly exert a damaging effect upon the numerous display cases throughout the building.

The new Field Museum, however, is provided with an excellent natural humidifier, in the form of Lake Michigan. Situated as it is, almost at the water's edge, the moisture laden winds from the lake prevent any condition of extreme dryness prevailing. Since the present building was erected numerous hygrometer tests have been made throughout the building under various temperature conditions, but at no time has the air been found too dry. In fact, certain exhibits which demand air of more than average dryness, have presented quite a problem in the working out of a method for keeping certain rooms dry.

The heating system comprises altogether, 1850 radiator units. There is installed a total of 121,162 sq. ft. of radiators and 17,000 sq. ft. of pipe coil. Over 200 T. of pipe was used. All steam piping is covered with an ample thickness of 85 per cent magnesia to reduce the radiation loss in the mains to a minimum.

All valves and fittings with the exception of those already mentioned are of Crane Co. make and McAlear steam specialties were used throughout.

Ventilating System for the Basement

Ventilation in the basement rooms is effected by two fresh air fans and four exhaust fans located in various sections of the building. The fresh air fans are used to supply air to the theatre and the north door, a fan with a capacity of 30,300 cu. ft. per min. supplying the theatre and a smaller one of 7500 cu. ft. per min. capacity supplying the north door. Each of these fans is fitted with filters and heating coils for the purpose of warming and cleaning the air before delivery into the rooms.

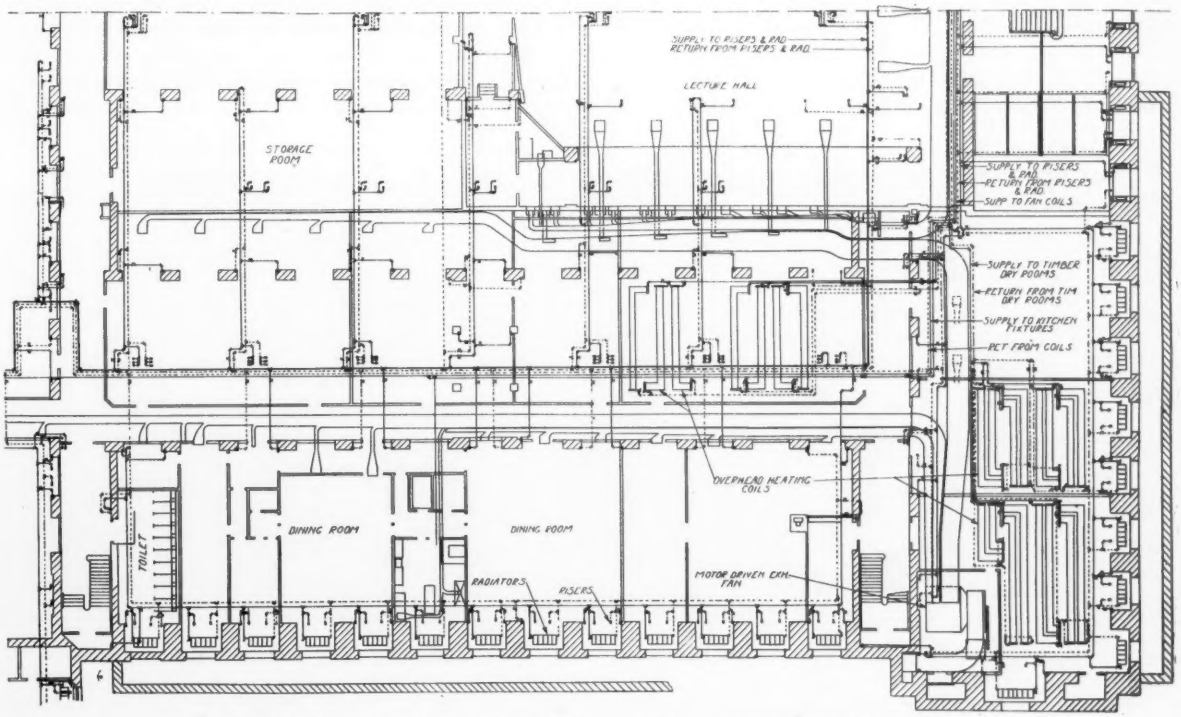


FIG. 9. DETAILS OF PIPING AND VENTILATING SYSTEM IN NORTHWEST QUARTER OF BUILDING

The four exhaust fans are located, one in each quarter of the building as shown in Fig. 6. They are in communication with the various rooms of the basement by means of an elaborate system of ducts and discharge the foul air to the outside of the building. The capacities of the four exhaust fans in cubic feet of air per minute are as follows: 25,500, 44,850, 36,650 and 25,000, giving a total exhausting capacity of 133,000 cu. ft. of air per min.

All fans are of the Sirocco type, made by the American Blower Co., and are driven by 220-v., 60-cycle, three-phase Western Electric Co. motors equipped with Cutler Hammer control apparatus.

Electrical Features

Three-phase, 60-cycle current from the lines of the public service company is delivered through under-

ground cables at a potential of 4000 v. and is stepped down to 220 and 110 v. by means of transformers installed in a special vault in the basement. This vault constitutes the public service company's substation and only the employes of that company have access to it. The secondaries of the transformers deliver current to a seven panel, black slate switchboard located in a room adjacent to the transformer vault, and from here the current is distributed throughout the building.

All lighting circuits are controlled from panel boxes installed in separate compartments and located at convenient points in the Museum. The system of lighting employed in the Museum, as may be expected, is of the most modern type. The exhibition halls with the exception of Stanley Field Hall, are lighted by means of 400 w. type "C" Mazda units installed in National X-Ray fixtures. Illumination in Stanley Field Hall is effected by six circular bronze chandeliers, each fitted with 121—50-w. white, type "C" Mazda lamps, operated by remote control from the first floor. As these chandeliers are suspended some 60 ft. above the floor, provision is made for lowering them for purposes of cleaning and replacing lamps.

The 124 offices and workrooms in the Museum are lighted by 75 w. lamps, the fixtures conforming to the needs of the individual installations.

A large part of the electric motor load is used in operating the elevators in the building, of which there are three. One is a 12-T. hydraulic lift, operating between the shipping room floor and the grade; another is a 6-T. freight elevator, operating from the shipping room to the 4th floor, while the remaining one is an 1800-lb. passenger car for the use of the curators and their assistants.

Conclusion

The entire building was designed by Graham, Anderson, Probst & White of Chicago, and Thompson-Starrett Co. were the general contractors in charge of construction. The heating plant was installed by Phillips Getschow Co. of Chicago. R. B. Hayward Co., The Hatfield Electric Co. and R. J. Powers installed the ventilating, electrical and plumbing work, respectively.

In conclusion, due credit is hereby extended to the Director of the Museum, D. C. Davies, and to W. H. Corning, chief engineer of the building, for assistance and privileges extended in the preparation of this article.

As a solution of investment problems and an encourager of thrift, Treasury Savings Certificates are of great help. They pay 4½ per cent interest compounded semi-annually if held for 5 yr. to maturity, increase in value each month and are not subject to market variations. They can be registered for the protection of the owner, are payable in cash on request and are backed by the good faith of the United States. They can be bought at any post office in denominations of $25, and $100, on the basis of $20 for the $25 certificate, and $80 for the $100 certificate, paying the face value of the certificate on maturity at the end of 5 yr.

To accumulate money for the purchase of Certificates, a Postal Savings account may be opened at the post office in which $1 or more may be deposited, the money accumulating, subject to withdrawal by the depositor, until sufficient is on hand to buy a Certificate, when the purchase can be made. Another method is to purchase Treasury Savings Stamps for $1 each, and when 20 of these are on hand, convert them into a Savings Certificate. By either method the amount saved is increased 25 per cent in 5 yr., or at the rate of 5 per cent a year with absolute safety of the principal and the possibility of withdrawal at any time should emergency make it necessary.

A study of the methods of mining coal is being made by the district and field engineers of the Bureau of Mines for the purpose of determining the percentage of extraction of coal, together with its relative degree of safety. When a sufficient number of mines have been investigated in any particular coal bed, it is planned to summarize the methods of mining in a bureau publication, calling attention to any unnecessary loss of coal in the different methods of mining operations. A large amount of this investigative work has been conducted in Alabama, Oklahoma, Kansas, western Pennsylvania and Utah.

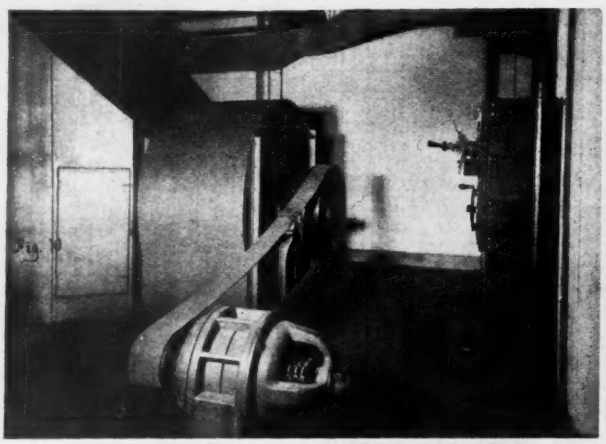


FIG. 10. ONE OF THE LARGE FRESH AIR FANS

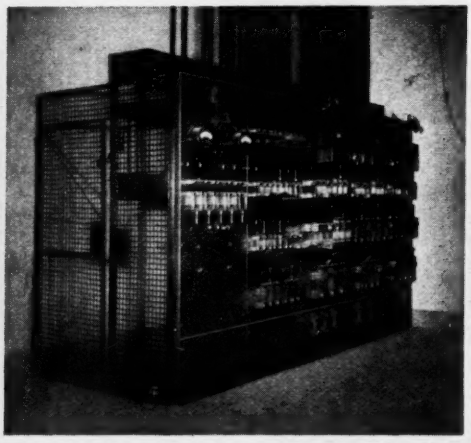


FIG. 11. THE MAIN SWITCHBOARD

The Expectation of Efficiency of Steam Boiler Operation

EMPIRICAL CURVES ENABLE THE EXPECTED EFFICIENCY OF A BOILER INSTALLATION TO BE DETERMINED WITH A FAIR DEGREE OF ACCURACY. BY HUGH R. CARR

AM I getting all I should out of this boiler plant? Every engineer, no doubt, has asked himself that question at one time or another, and has endeavored to answer it by the method most suitably adapted to his plant. Before going into the matter, however, he must first ask himself, what is to be expected? Of course, an extensive boiler test will give him the information, but boiler tests are expensive propositions and he usually casts about for another method. The next best thing is to base his expected efficiency upon conclusions drawn from tests made elsewhere. It was with this idea in view that the writer collected data and put it into graphic form so that it would be an aid in plant operation.

For many years, a record of tests has been kept covering various grades of coal, types of grates or stokers, various boilers, and settings. If these are segregated and tabulated, it is possible to get empirical information regarding the expected variation of combined boiler, furnace and grate efficiency with changes in certain general conditions in furnace design and operation.

The variables readily divide into five general heads: type of draft, combustion rate, coal, ratio of heating to grate surface, and last but not least, the point of maximum heat intensity. If sufficient data was available any of these might be subdivided and tabulated. In absence of such data we can obtain a hint regarding the possible subdivisions by reasoning from the theory and known data on combustion of coal under steam boilers.

The most common variable is the combustion rate which, of course varies with the boiler rating. The curve shown in Fig. 1 is plotted to show the expected variation of efficiency with the combustion rate, all other factors being constant. The constant factors were taken as the maximums commonly found in practice, the coal at 14,500 B.t.u. per lb., the ratio of heating to grate surface at 80:1, and an average distance of fuel to boiler tubes of about 8 ft., this now being what is thought to be a good value for elimination of high flue temperature due to the point of maximum heat intensity being too far along on the passage through the boiler. These limits were taken as being about the highest found in general practice. The curves, therefore, must not be taken as fitting every case, but do give reasonably close values to be an aid to general operation. They will not predetermine test results, although they will check within 1 or 2 per cent of test results.

It will be noted that there are two curves given covering these high limits of the other variables, one for forced (and nearly balanced) draft, and one for natural draft, the latter falling off much faster than the former. The most evident reason for this is the high draft over the fire required in the natural draft furnace. With balanced draft, a draft over the fire should be maintained at about 0.10 in. of water; but with natural draft this low limit is possible only with low combustion rates, even at about 20 lb. of coal burned per square foot of grate surface per hour about 0.25 in. is required, and at 30 lb. about 0.45 in. With high draft over the fire the losses due to the infiltration of relatively cold air and to fine coal being sucked up through the boiler are quite large. There are probably other minor losses of which little is known. The curve dotted in is for the same ratio of heating surface to grate surface and forced draft but corrected to 10,500 B.t.u. coal. This gives an idea of the effect of the coal on the efficiency.

CORRECTION FACTORS

CORRECTIONS ARE, of course, in order for various grades of coal and the other factors. Two corrections are made for the coal, one in Fig. 1 and the other on a correction curve shown in Fig. 2. Two such correction

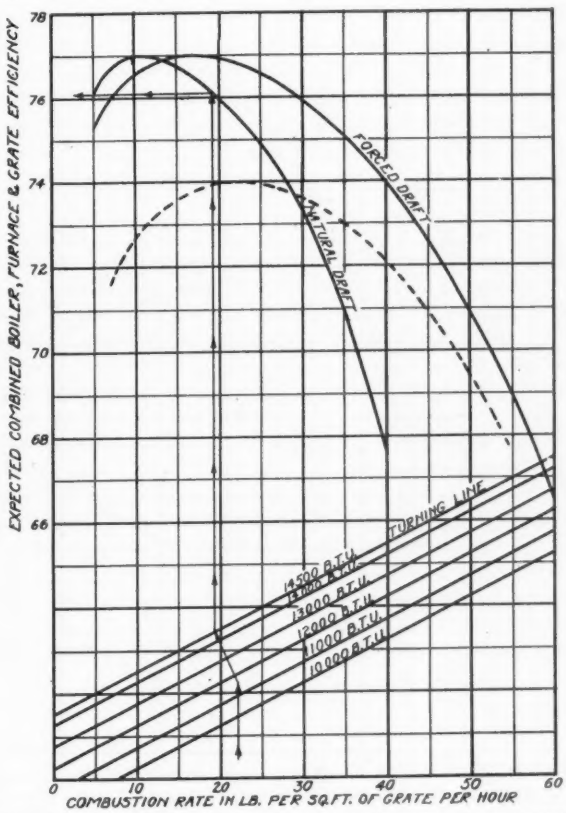


FIG. 1. EXPECTED VARIATION OF EFFICIENCY WITH COMBUSTION RATE

curves are plotted in an effort to take into account the effect of the distance from fuel bed to tubes. On most old hand-fired settings, or where overfeed or the flat bed type of underfeed stoker have replaced old hand grates, the average distance from fuel bed to tubes is quite short, even as short as 4 ft. in the worst cases. A very limited amount of data is available on old settings, but what there is indicates that a change of 3 ft. causes considerable decrease in efficiency with low grade coals. This is reasonable because it is well known that the higher the volatile matter in the coal burned, the greater the distance from the fuel bed the combustion is com-

pleted. The top correction curve checks out very nicely and the lower curve seems to serve its purpose for the older low settings. The use of the upper curve for settings where the average distance from fuel bed to tubes is around 8 ft. and the lower for distance around 6 ft. is consistent enough for use with these curves as it is reasonable to expect a slight error from the use of empirical data such as this.

The correction for the ratio of heating surface to grate surface, also in Fig. 2, is probably largely necessary, due to the fact that the heat transfer, as a whole, on a large tube surface is greater than that over a smaller surface. If equal volumes of gas are given off from a square foot of grate more heat will be absorbed by the greater tube surface because the velocity of the gas over the surface will be less and the time of contact of the gas with the tube surface will be longer.

Possibly the reasons for the reductions in efficiency with lower grades of coal are the most numerous. A few come to mind. Generally, the lower the grade of coal, the higher the ash content. Since per cent combustible in the refuse does not decrease with an increase in ash content in the coal, in fact it generally increases slightly, the actual combustible loss is increased with an increase of ash in the coal and doubling the ash content in the coal means about double the combustible loss and almost double the percentage heat loss. The low grade fuels are generally high volatile and high moisture coals. The losses due to the heating of the free moisture in the coal and that formed by the combustion of the volatile matter are considerable with the low grade coals. The heat intensity in the furnace is also affected by the grade of coal.

The coal correction in Fig. 1, mentioned before, is not exactly a correction for losses, but is really a correction for the scale of the curve. The logical combustion rate scale would be "pounds of combustible per square foot of grate," and this correction makes it possible to get the same result but using the more common term "pounds per square foot of grate surface."

Calculation of Combustion Rate

In connection with the use of the curves a formula has been derived for simplifying the necessary calculations required to determine the combustion rate for a given rating and coal. From fundamentals:

Pounds coal per sq. ft. grate =

B.t.u. removed from boiler in steam per sq. ft. grate

B.t.u. per lb. coal × efficiency

= (rated hp. per sq. ft. grate) × 34.5 × 970.4 × per cent rating ÷ (B.t.u. of coal × 100 × efficiency)

= (sq. heating surface ÷ 10) per sq. ft. grate × 34.5 × 970.4 × per cent rating ÷ 100 (B.t.u. of coal × efficiency)

= per cent rating × ratio heating to grate surface × 33.4 ÷ (B.t.u of coal × efficiency)

$$= \text{per cent rating} \times \frac{33.4 \times \text{ratio}}{\text{B.t.u. of coal} \times \text{eff.}} = \text{lb. coal burned per sq. ft. grate.}$$

This expression, of course, uses the very thing that the user is trying to determine, the combined boiler,

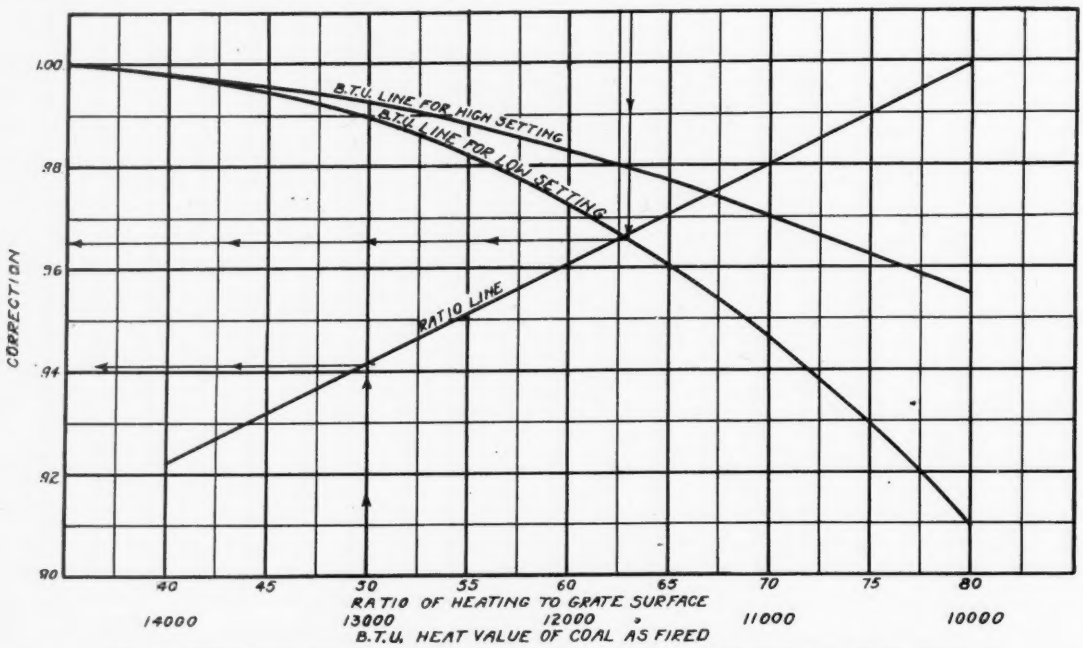


FIG. 2. CORRECTION CURVE FOR TYPE OF SETTING AND RATIO OF HEATING TO GRATE SURFACE

furnace and grate efficiency. It is therefore necessary to assume an efficiency, determine the combustion rate, then the expected efficiency, and if the result is not close to that assumed, try again with another assumption.

Method of Using Curves

The procedure in using these curves is as follows: Assume an efficiency, determine the combustion rate for the boiler rating wanted, using the formula given above, run up the line in Fig. 1, representing this combustion rate to the B.t.u. line representing the heat value of the coal, then perpendicular to the B.t.u. lines to the turning line and then vertical again to the forced draft or

natural draft curve as the case may be. Then in Fig. 2 pick off the coal correction at the intersection of the proper B.t.u. line with one of the coal correction curves (use the lower curve if the distance from the average point on the fuel bed to the tubes is near 6 ft. and the upper curve if this average distance is near 8 ft.). Then divide ten times the rating of the boiler by the square feet of grate area and then find the ratio correction from the intersection of the ratio line and ratio curve. According to general boiler practice, the heating surface of the boiler is equal to ten times the rated horsepower. Multiply the result from Fig. 1 by one of the corrections and the result of this by the other correction to get the expected combined efficiency.

The heat value of coal as fired, which is the value upon which these curves and corrections are based, can be considered for this work as equivalent to: B.t.u. on dry basis $\times$ (100 — per cent moisture in coal) $\div$ 100.

As examples of the use of the curves, data is given below for a modern forced draft setting and an old natural draft installation. This particular data was taken from a reference familiar to practically all engineers, table No. 59 in the handbook, "Steam," published by the Babcock & Wilcox Company.

	Installation No. 1	Installation No. 2
Rated boiler horsepower	604	295
Grate area	75	59.5
Type of grate	Underfeed stoker	Hand grate
Type of draft	Forced	Natural
Setting height	Modern	Old low
Per cent boiler rating to be attained	160	100
Heat value of coal (dry)	14,105	12,060
Per cent moisture in coal	2.20	3.04
Calculated results:		
Ratio heating to grate surface	80	50
B.t.u. of coal as fired	13,780	11,700
Assumed efficiency (per cent)	70	65
Combustion rate (by formula)	44.5	22
Efficiency value from Fig. 1 (a)	73.0	76.1
Coal correction from Fig. 2 (b)	.995	.965
Ratio correction from Fig. 2 (c)	1.00	.941
Expected efficiency (product a, b and c)	72.6	69.1
Combustion rate in this efficiency	42.7	21
Efficiency value for this rate from Fig. 1	73.5	76.4
Coal correction (as before)	.995	.965
Ratio correction (as before)	1.00	.941
Expected efficiency	73.1	69.0
Corresponding rating of boiler	161	101
Test results showed:		
Combined efficiency	73.5	69.6
At a per cent boiler rating of	158.6	107.2

Referring to installation No. 2, we will assume the efficiency given in the tabulation, i. e., 65 per cent. By means of the formula given above, we determine the combustion rate for this boiler as follows:

Lb. coal per sq. ft. grate surface =

$$100 \times \frac{33.4 \times 50}{11{,}700 \times 65} \text{ or}$$

22 lb.

Locating this value (22) on the lower scale in the curve, Fig. 1, we run vertically upward to 11,700, the B.t.u. line of the coal. Running in a direction perpendicular to the B.t.u. line to the turning line and then vertically upwards to the natural draft curve, we obtain the first expected combined, boiler, furnace and grate efficiency, in this case 76.1.

Referring now to the curve, Fig. 2, we pick off the coal correction at the left of the intersection of the 11,700 B.t.u. line with the correction curve for a low setting. This correction, as will be seen, is 0.964. Now, dividing ten times the rating of the boiler by the square feet of grate surface, we obtain

$$\frac{295 \times 10}{59.5} = 50 \text{ approx.}$$

Locating this value on the bottom scale in the curve Fig. 2 and running upward to its intersection with the ratio line, we obtain at the left, the correction 0.941.

Multiplying the result from the curve in Fig. 1 (76.1 by the two correction factors (0.964 and 0.941) obtained from the curve in Fig. 2, we have,

$$76.1 \times 0.964 \times 0.941 = 69 \text{ per cent.}$$

These particular examples check better, perhaps, with the test results that might be generally expected. In the worst case, however, the difference should not be over 2 per cent.

There are also cases where a higher efficiency than the curves show may be expected. Such conditions might prevail in such unusual settings where the gas passage is extra long, as in four pass boilers and those with unusually high tubes. The writer has heard of cases where the efficiency has been found to be as much as 2 per cent higher than expected when the gas passages were extremely long.

Conclusions Drawn from Curves

A study of the curves brings out the reason for many things we have all noticed and not realized, for example: on natural draft installations the ratio of heating surface to grate surface is generally from 40:1 to 55:1. The expected efficiency at the lower ratio is higher than at the higher, due to the greatly increased combustion rate required to get the same boiler rating. It can be seen that this is true also for forced draft, but not to so great extent, and in this latter case the maximum combustion rate is also a factor in choosing the ratio. A combustion rate of 50 lb. per sq. ft. of grate is about the limit for narrow furnaces, due to the greater relative effect of clinkers on the side walls hindering combustion. On wide furnaces this effect is not so great and as high as 60 lb. per sq. ft. of grate can be burned. For short periods greater rates than these have been attained but for continuous burning these rates are about the limit. One-half to two-thirds these values are good limits for natural draft.

In this connection may be mentioned a method for determining the number of boilers to put on the line in anticipation of a rise of load. Determine the expected efficiency for the combustion rate which can be safely used and then from the formula given above determine the maximum boiler rating which can be expected. From this it is easy to determine the total horsepower to have ready to take care of the load.

In like manner, excellence of operation remaining the same, the relative value of two coals can be closely predetermined. We may express the characteristics of the coals in algebraic terms as follows:

Let A = the heat value of the poor coal.
B = the heat value of the better coal.
p = the expected efficiency if the coal A, is in use.
q = the expected efficiency if the coal B, is in use.

Then the relative value of the coal of heat value A, to

the coal of heat value B, is $(A \times p \div B \times q)$ 100. This value is then the per cent equivalent of the low heat value coal to the higher. If this value is greater than the per cent expressed by the ratio of the cost of the low grade coal to the higher grade, then, from a standpoint of efficiency only, the low grade coal is the most economical. Practically, possible mechanical troubles incidental to the burning of the low grade coal and also the slight added cost of handling this coal and its ash must be taken into account. These latter factors can be accounted for from plant operating and maintenance records. Without data similar to these efficiency expectation curves, elaborate tests would have to be run to determine advisability of change of coal.

Again, a study of the curves will show the possibility of the use of a variable grate area for keeping the combustion rate near the point of peak efficiency. Reduction of the active grate surface at low ratings will considerably increase economy.

These few applications of the efficiency expectation curves give an idea of the possible uses to which they may be put. Many other applications are possible and aid greatly the engineer who has problems involving furnace operation.

Pyrometers in Waste-Heat Boiler Plants

TYPES, LOCATIONS AND USE OF HIGH TEMPERATURE RECORDING INSTRUMENTS. BY J. HOWARD TORREY*

WASTE-HEAT boilers can be advantageously installed wherever large quantities of hot gases are discharged into free air frequently and regularly, if not continuously. The principal industries which come under this head are: Cement plants, smelting furnaces, openhearth furnaces, water-gas plants of large output. I have omitted ceramic plants, as the hot gases from their kilns are usually utilized to dry unburnt ware, and therefore not wasted.

For the successful operation of waste-heat boilers, pyrometers are of prime necessity and the installation should be as comprehensive as possible.

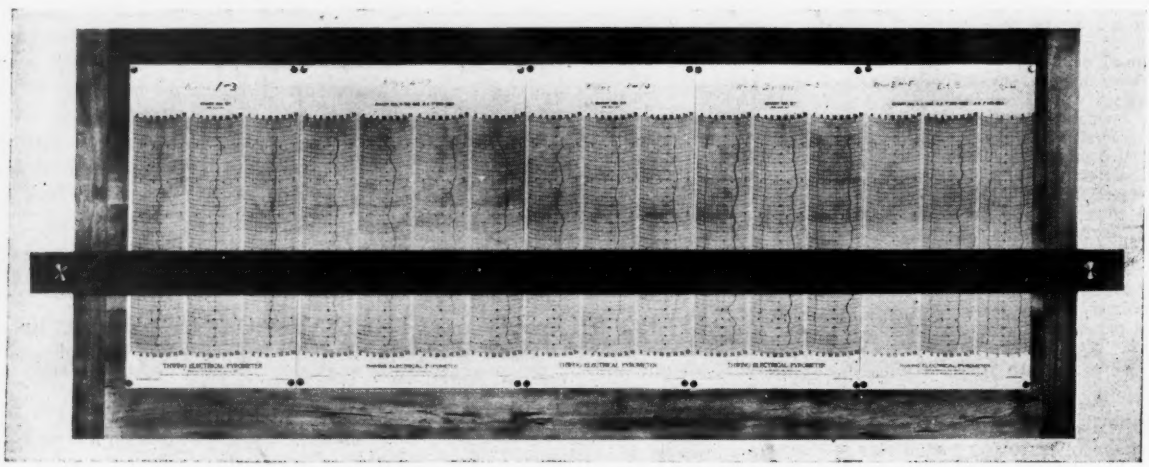
Of the list of industries mentioned, the cement manufacturers are now displaying the most interest in this subject, and it is quite generally conceded that a cement plant, to live and prosper, must, as a matter of self-preservation, install waste-heat boilers to utilize the volume of B.t.u. which leave their kilns in the form of hot gases. Such gases contain a greater or less amount of CO in addition to CO_2, O_2, and SO_2. That CO is present is proven by the fact that temperature of gases entering boilers is usually higher than that of gases at kiln housings.

Power is required crushing and pulverizing "raw," and the same for "clinker"; pulverizing coal for kilns (when such fuel is used); and filling and loading bags, as well as many other purposes. With efficient prime movers and motor equipment throughout, it is possible to generate 100 per cent of the power required for such purposes. This is being done at the plant where the writer installed one of the first pyrometer outfits in connection with waste-heat boiler work and cement kilns.

A recent pyrometer installation made by the writer in a cement plant (10 kilns and 5 waste-heat boilers without economizers) will serve as an illustration of what is available, and shows the large amount of co-related data which may be obtained in condensed yet comprehensive and readily observed form.

On three straight, 27-hr. charts, aggregating ten 3-in. sections, were recorded temperature of gases in kiln housings. These records were made by two three-galvanometer, three-record recorders and one four-galvanometer, four-record recorder and, in addition to the information given by the temperature records, also served to show the continuity of operation of each kiln. These three recorders were placed in the head burner's room, where each burner, or kiln operator, could observe his kiln record from time to time.

In the waste-heat boiler-room were installed two three-galvanometer, six-record recorders, each using a three-section (3 in. per section) 10-in. chart. A section is



METHOD USED FOR COMPARING PYROMETER READINGS

*Engineer for Thwing Instrument Co.

devoted to each of the five waste-heat boilers and carries two records—gases entering boilers, and gases leaving boilers. Had these boilers been equipped with economizers, there would have been on each of these five sections a record of temperature of gases leaving economizer, or three records per section. On the sixth section two records are also carried—temperature of superheated steam and temperature of water entering boilers.

As the five charts were placed on the general manager's desk each morning, the writer suggested that a rack be built on wall with pins spaced to fit holes punched in top of charts. The holes in top of charts were located so that when charts were hung in proper position, the time lines for any hour, say 10:00 a. m., were on a line horizontally. A horizontal, traveling ruler, of sufficient length to reach across all five charts was provided. With this arrangement, the general manager could instantly observe what had taken place as regards temperature fluctuations at any time during the day previous, and could also readily refer to periods farther back.

The thermocouples installed in the 10 kilns (in dust catchers) had extra heavy elements with best grade of nickel-chromium protection over portion exposed to high-temperatures. The same style of thermocouples were installed where hot gases enter five waste-heat boilers. For the gases leaving each boiler five lighter weight thermocouples were used as temperatures were not high.

With this particular installation, the cold-ends of these 20 thermocouples were all carried by means of cold-end extension wire to three thermostat boxes in which a temperature of 120 deg. F. is constantly and automatically maintained.

For the two thermocouples measuring the temperature of superheated steam and water entering the boilers, the extended cold-ends were buried 10 ft. underground, as it was desirable to obtain as low a cold-end temperature as possible. At 10 ft. underground, the temperature was found to vary from 55 to 60 deg. F., or 2½ deg. F. plus or minus throughout the year. All cold ends would have been buried had it not necessitated greater expense for drilling.

The managements of some cement plants consider it advisable to have records of temperature of "clinker" passing through the "burning zone" and for this purpose use a recording radiation pyrometer. Where oil is used for fuel, it is essential that close tabs be kept on temperature of kiln lining in the "burning zone," as with oil the brickwork is very easily damaged with resultant shutdowns for patching. A radiation pyrometer furnishes the only satisfactory means of recording such temperatures, as the "burning zone" is inaccessible for thermocouples except in connection with a water-jacket and that is decidedly objectionable.

In installing pyrometers in waste-heat boilers, the same basic principles must be observed for all cases. The designing engineers first ascertain volume and temperature of gases going to waste, and on such data is based the waste-heat boiler manufacturer's guarantee. Pyrometers are absolutely necessary so that temperatures on which guarantees are based are at least maintained; this refers to temperature sources.

As regards thermocouples located in boiler entrances, boiler exits, and economizer exits, the need for the first of these three is readily seen as there are usually more temperature sources (exhausting hot gases at fluctuating temperatures) than waste-heat boilers. With thermocouples located in boiler exits, and recording on same section with their respective boiler entrance thermocouple, the heat absorption in each boiler may be instantly known. When there is an economizer with each boiler, three records for each boiler are made on the same chart section.

When the information each pyrometer chart section tells as regards heat absorption is checked up against draft and water evaporation records, the efficiency of boiler is known and warning given as to condition of tubes and flues.

In some cases, it is preferable to furnish indicators for the operators to go by, while the recording pyrometers are located in the plant office. This may be done, irrespective of distance, as with the high resistance galvanometers employed no error is introduced in either indicator or recorder.

Lubrication and the Steam Boiler

By Edward L. Gross*

LUBRICATION of steam driven units, both of the reciprocating and steam turbine type, has been reduced to a nearly exact science. Knowing the type of engine, load to be carried, revolutions per minute, temperature of steam, etc., the character of lubricant to be employed can be definitely determined by those versed in the art. It is not my purpose, therefore, to discuss this particular phase, but to bring to your consideration the relation of the steam boiler itself to the lubrication problem.

Not only do certain phenomena occurring in the steam boiler materially affect engine lubrication but, in turn, the lubricant employed in the engine itself plays an important role in the operation of the steam boiler.

In steam engines, with few exceptions, all of the steam that is exhausted contains oil that has served its useful purpose as a lubricant and if the steam is condensed and returned as boiler feed water, considerable of this oil gets back into the boiler and is capable of doing harm.

One of the advantages possessed by the steam turbine, as compared to the reciprocating type of steam engine, is that when it is operated condensing, no oil gets into the condensate. A surface condenser can be employed and the condensate returned to the boilers practically free from lubricant, without the necessity of oil separators.

It has been estimated that the insulating power of a thin film of oil on the heating surface of a boiler is much more than that of scale averaging 1/16 in. thick. In addition, the scale that is formed by the

*Vice-Pres. The Perolin Co. of America, before the Am. Soc. Lubri. Eng.

collecting of light floating material by the surface film of oil settling on the heating surface, is even worse than ordinary scale, because in addition to causing a loss of heat, it also causes corrosion of the metal.

One would naturally infer that, as oil is lighter than water, it would remain on the surface, but this is not the case. Oil comes in contact with the small particles of lime, magnesia, etc., and by sticking to them soon becomes as heavy as the water, with the result that it is carried around by the circulation and coming in contact with the metal, sticks to it. This explains why the under sides of the boiler tubes are liable to become coated with a mixture of incrusting salts and oil residue as well as the upper sides.

Insulating effects of a thin film of oil on the heating surface are surprising. In a test made by Sir John Durston, with fire temperatures ranging from 2190 to 2500 deg. F., the temperature of metal at the bottom of an iron vessel, ½ in. thick when the surface was clean, was 280 deg. F. On mixing 5 per cent mineral oil with the water, it rose to 310 deg. F., and when the bottom of the vessel had a coating of grease 3/64 in. thick, it rose to 518 deg. F.

Mineral oils deposited on a boiler plate form a coating similar in appearance to brown varnish, which readily results in overheating of the metal and burnt and bagged sheets. It is a rather peculiar state of affairs that in spite of the fact that power plants spend a large amount of money in installing fairly efficient oil separators in the exhaust steam line, and in spite of the well known harmful effects of oil films on heating surfaces, engineers in some plants still employ crude oil as a boiler scale preventive and for the purpose of stopping boiler foaming and priming.

In reference to the corrosive action of scale containing oil, it can be readily seen that oil can be chemically active only as result of compounding, since the average cylinder oil contains between 2 and 10 per cent of organic compound. Under the high temperatures prevalent in steam boiler practice, animal and vegetable oils are decomposed with resultant formation of organic acid, and consequent pitting and corrosion of the plate. It would appear to the writer, therefore, that in compounding oils, some consideration should be given as to whether or not the engine in which they are to be employed runs condensing or not, and if the former is the case the oil should be prescribed, other things taken into consideration, with the minimum compounding.

The effect of oil in a boiler and the effect of the boiler on the oil in the engine is intimately related to that common trouble known to engineers as foaming and priming, terms which are very often confused. Foaming consists of steam bubbles building up upon the surface of the water instead of breaking and releasing steam. It becomes serious only when the bubbles form rapidly and hang together long enough to reach the point where the steam is supposed to be taken off; then a sort of a siphoning action takes place and a large amount of water is carried over entrained with the steam. Priming, on the other hand, is due to a sudden evolution of steam from the heating surface, very similar to the so-called "bumping" which takes place in laboratory apparatus during distillation, and is due either to poor design of boiler, overload, or a sudden demand for steam. In some instances it occurs in boilers where the heating surface is coated with a heavy scale, due to a sudden release of the incrustation from the metal so that the water strikes the over-heated surface resulting in an extremely rapid generation of steam. In both cases the steam carries over large amounts of water. Priming is altogether different from foaming and can, to a considerable extent, be controlled mechanically.

While all the causes producing foaming are not as yet definitely established, large amounts of suspended matter in the boiler water, and the presence of oil, are sources of trouble in this respect. One of the most active salts producing foaming is sodium carbonate, commonly known as soda ash, which is employed in many power plants either in water softening apparatus, or in the boilers themselves, for the purpose of removing and preventing scale formation.

Foaming and priming of steam boilers are directly related to the lubrication of the steam engine itself. As above explained, when these two phenomena, or either one occurs, large quantities of water are carried over with the steam. Boiler water runs fairly high in salts, such as calcium and magnesium carbonates and sulphates, which are naturally carried over with the water; due to their sandy or gritty nature, they seriously interfere with lubrication of the engine cylinders. These salts tend to combine with the organic constituents of the lubricant, forming insoluble soap, which greatly interferes with the efficient working of the lubricant itself and results in the familiar sticking or groaning taking place in steam engines when foaming or priming of the boilers occurs. When soda ash is employed in the boiler, quantities of this are also carried over with the steam, intensifying the harmful action of the salts themselves and cutting the entire oil film from the rubbing surfaces.

In turbine practice, oil is always contaminated with water which leaks through the packing glands. In cases of serious breakdowns of turbine lubrication, examination of the emulsified oil has shown the presence of these salts carried over with the boiler water.

To sum up briefly, therefore, in prescribing lubricants for steam engine practice, some consideration should be given to the fact that quantities of the oil may get into the boiler with the condensate and an oil prescribed which will prove to be the least harmful under these conditions. Provision should be made in those plants where condensate is employed, to see that efficient oil separators are installed in the lines to remove as much of the oil as possible previous to the entrance of the condensate into the boiler.

In those plants where foaming or priming is common, careful investigation should be made by an expert to determine the causes thereof and an effective remedy found for preventing, or at least alleviating, this trouble. Where foaming and priming are due to improper boiler design, or to extremely sudden demand for steam, some protective arrangement should be inserted in the steam line to protect the engine and turbine against interruption of efficient lubrication, or possible complete wreckage. The amount of lubricant which will give the most efficient working should be noted for each individual engine and provision made to avoid excess lubrication.

Operation of Hydraulic Power Plants

Constant Attention to Operating Details Is Essential to Economic Power Production

CONTRARY TO general popular opinion, hydroelectric plants are not altogether automatic in their operation. The thought behind this opinion is that once a hydraulic generation station is installed and put in operation, it will remain in operation indefinitely and will continue to develop power as long as there is water in the river. To the casual observer the cleanliness, the quiet, the order, the apparent lack of attention is apt to leave such an impression.

Such, of course, is not the case; here, as in any other kind of plant, the price of efficiency, economy, and continuity of service is constant watchfulness. Trouble is forever ready to break out and the management must therefore be constantly on hand to see that it does not. The efficient management must do more than that; it must keep a step ahead and see trouble coming before it arrives, and take precautions accordingly.

In the more northerly sections of the country the greater part of the difficulties that arise occurs during the winter season, due to ice formation.

Ice occurs in three forms; surface ice, which forms first along the edges of the river or pond and then gradually covers the whole surface of the open water; anchor ice, which forms around boulders and irregularities of the river bed; and frazil ice, which forms in turbulent waters and permeates more or less the whole body of water to a depth of several feet.

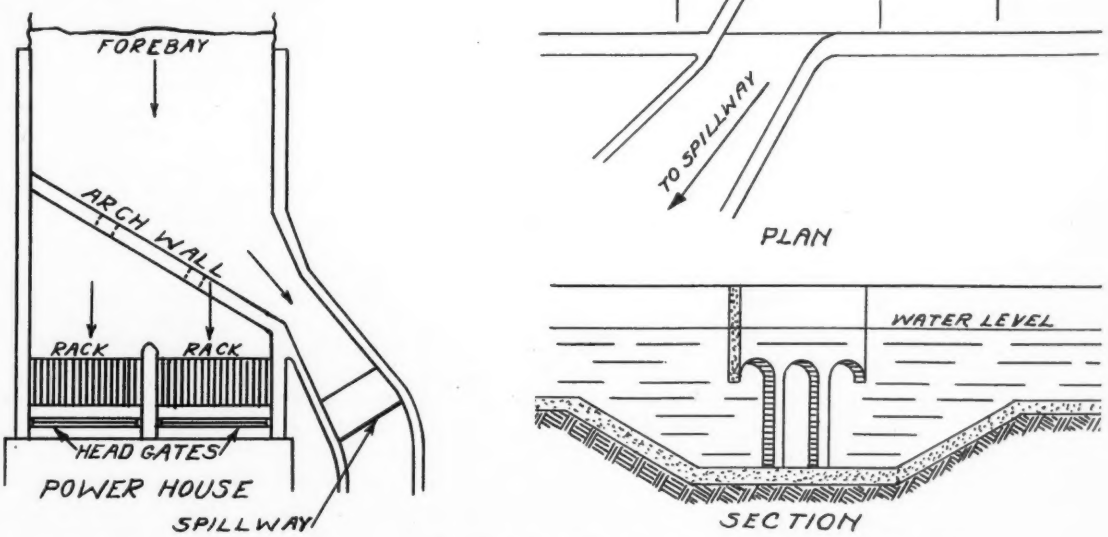


FIG. 1. ARRANGEMENT OF DEFLECTING ARCH TO KEEP ICE AND TRASH FROM HEAD RACKS

Contending with Surface Ice

Surface ice causes trouble for the hydraulic engineer by piling up on the intake racks where it is effective in curtailing the flow to a large degree. The remedy which suggests itself is to provide means for keeping it back and away from the plant.

In well designed plants, this point is considered beforehand and some means provided to accomplish this result. One method is to provide a barrier in the form of a submerged arch across the forebay, inclined at an angle of about 60 deg. to the direction of flow, somewhat as shown in Fig. 1. This arch, or rather series of arches, is submerged about 3 ft. more or less, depending on the severity of the climate; and the solid crown extends above the surface about an equal amount. Such an arch permits the water to flow beneath but forms a barrier to the ice on the surface. At the down stream end of this arch there is provided a sluice-way through which ice accumulations may be passed off and thus bypass the plant. If surface ice interferes with the operation of the plant and if such a wall or its equivalent is not included in the layout of the plant, one should be placed at the first opportunity. In the meantime, some degree of protection may be afforded by stringing a log boom across the forebay in the same position that an arch would occupy, with the one exception that the angle of the boom with direction of flow should be less.

To be effective with a heavy ice formation, the logs forming the boom should be of ample size to prevent slabs of ice from being forced under. For this purpose the log should project 16 or 18 in. below the surface. For pine, spruce or fir, this would mean that the log would have to be about 3 ft. in diameter. As the forces acting on such a boom are of considerable magnitude, the logs making up the boom must be securely spiked

together; usually heavy 3-ft. chain dogs will be found to suffice for the purpose.

Surface ice is also liable to cause damage to the flash boards of the dam by adhering there and dislocating the whole structure in case of a rise or fall of the forebay level. This difficulty may be satisfactorily disposed of only by maintaining an open channel along the face of the dam adjacent to the flashing. The method usually employed to effect this result is simply to go out with an ax and chop away the ice as it forms. This would require a continual application of effort if the water surface were to be kept entirely open, but, as a rule, a thin formation of ice is not likely to cause any disastrous consequences so that a thin layer of ice is allowed to form between cleanings, which materially reduces the amount of labor required.

In some cases where labor is difficult to obtain, the flashing may be kept free by running a steam line along the boards at the crest level, through which steam may be circulated at intervals when conditions require it.

At an installation which recently came to our attention, this situation was met in a somewhat unusual manner. The dam at this plant is not exceedingly wide nor is the flow over abundant for the demand.

FIG. 2. SETTLING BASIN TO SEPARATE OUT GRAVEL CARRIED ALONG IN THE STREAM

For this reason the capacity of the plant is augmented by a steam turbine unit. Condensing water from the condenser of the unit is taken from the river at a point just ahead of the flashing and is ordinarily discharged into the tail race to minimize the pumping requirements. There is, however, an auxiliary discharge located on the far side of the forebay directly upstream of the flashing where the condensate discharge may be disposed of when so desired. When ice begins to form on the flashboards, the waste condensing water is directed to this discharge. With a discharge at one end of the dam and an intake at the other, there is established a flow of warm water across the bay just in front of the flashing which has been found exceedingly effective in maintaining an open channel along the flash boards. This arrangement cannot of course be used in all plants because there is not always available a supply of warm waste water; but where such waste is available it should be utilized if possible.

Overcoming Anchor and Frazil Ice Troubles

Anchor ice will cause no trouble if it remains where it is formed, but there are conditions under which it will be dislodged and will pile up against the head gate racks and will thus curtail the flow. Where iron racks are exposed at their upper ends to an atmosphere below freezing, anchor ice will form on the grids and will eventually block up the entire passage. This formation can be disposed of by chopping it away or by running a steam rake up and down the rack or probably better by heating the tops of the racks and knocking off the loosened ice. In many plants the rack tops are permanently housed in and heated in the winter so that this difficulty may be eliminated. This is an excellent arrangement but is not always practical in some plant designs.

Frazil ice is ordinarily encountered for only a comparatively short period of time during the early part of the cold season just preceding the formation of permanent surface ice and when there are usually high winds and the surface of the pond is turbulent. Considerable agitation is necessary for the development of this formation, otherwise solid ice would be formed on the surface instead. Such ice does finally form, of course, and when it does frazil ceases to form and what there is of it in the water gradually attaches itself to the under side of the surface ice and forms a kind of inverted dam which is not altogether impervious to flow, but which, in a narrow channel such as a canal, may seriously curtail the water supply to the penstocks.

At locations where there is a considerable pond area above the head gates that is fairly well protected from wind, frazil will not cause a great deal of difficulty. Where there are rapids above, which keep the water in a constant turmoil, frazil ice will be formed and will be carried down to the racks.

This formation of ice consists of minute individual crystals which are interspersed throughout the body of the water to a depth of several feet. It has the property of adhering fast to any cold body, at or below a temperature of 32 deg. F., with which it may come in contact. It crystallizes out on head racks where the ends are exposed and will quickly close up the whole opening unless the grid is heated in some way. This may be accomplished by housing in the racks as mentioned previously. A temperature of only a fraction of a degree above the freezing point is sufficient to prevent the crystals from attaching themselves to the grating.

Even penstocks, guide vanes, and runners of the turbine form a lodging place for these crystals when the turbine is so installed as to prevent radiation of heat to these parts, as for instance when the whole turbine casing is imbedded in concrete. Once this formation starts, it builds up rapidly and the turbine is forced to shut down. When this happens, the water remaining in the casing, due to the damming effect of the frazil accumulation, quickly solidifies and then it is a matter of hours or a day, possibly, chopping out the ice so that the turbine can be run.

In some installations where such a freeze-up is likely to occur, the turbine casing is enclosed in an outer casing, leaving a small space between to which steam may be admitted. A simpler method, though perhaps not as immediately effective, is to put two or three coils of pipe around the crown and bottom plates and connect them with a steam supply. Where the turbine casing is directly exposed to the generator room

temperature, frazil formations will be found to give little trouble, but it is questionable whether or not this method of keeping the turbine above the freezing point is as economical as it might be.

Head gates, remote from the power house and more or less exposed to the weather, may be rendered inoperative, if left in the closed position, by becoming frozen in. Exposed gates should be piped with steam coils by means of which they may be thawed out when necessary. otherwise the job of freeing a gate is a question of manual labor which may at times prove rather strenuous.

Where gates are electrically operated and remote controlled, they are usually well housed in so that freezing in is not met with as frequently.

Removing Trash from Water

Aside from the troubles caused by ice, there are those occasioned by trash and gravel carried along in the stream. All hydraulic plants are equipped with head racks that serve to prevent logs, branches and other debris from getting into the penstock. Such debris accumulates rapidly and will clog up the racks unless it is cleared away periodically and carried off through the sluice way.

A considerable loss of head and a greater power loss may occur at this point through neglect because if the turbines are properly chosen for the normal head, any reduction in head caused by trash accumulations will cause the wheels to operate at the wrong speed for best efficiency. This loss, especially in low head plants, may become actually serious.

The bars making up the rack are so spaced that nothing will go through that will be likely to lodge in the turbine; however, such a rack will not keep out gravel and such material. Some streams carry along in the current great quantities of gravel and coarse sand which if allowed to pass through the turbine will exert excessive erosive action and rapidly wear through the turbine blading and guide vanes.

For the purpose of removing this gravel, some kind of settling basin should be provided, where the gravel may be precipitated and subsequently flushed out. The accompanying photograph shows a view of such a gravel settler at the Halsey Power Plant of the Pacific Gas and Electric Co., located on the Bear River. Water enters through the gates in right background and passes out through the channel shown in the foreground to the right, leaving the gravel in the settling basin in the center. By opening the sluice gates, the gravel is flushed out into the river and so bypasses the plant.

In any number of manufacturing plants using both steam and water power, the steam plant usually receives most excellent attention as compared with that which the hydraulic plant receives. The thought seems to be that the water power costs nothing after the initial investment, due probably in a large degree to the absence of what would correspond to a coal bill every month. It should be remembered that for a given power demand every horsepower developed by water power means just that much less load on the steam units with the consequent reduction in the fuel bill.

To this end the operating conditions should be carefully studied. Curves showing efficiency and capacity for given gate openings and heads should be available so that the load may be distributed to the best advantage. It may be, for instance, that maximum efficiency and nearby maximum capacity is obtained with, say, 0.80 gate, in which case it is certainly poor practice to operate with full gate using more water than is necessary.

Reduction of head from any cause, trash accumulations or otherwise, is to be avoided. Partially opened gates, due to inferior rigging or incompetent labor, will cause a reduction in head due to the restricted opening, and should not be countenanced. Loss of effective head may be greatly augmented by incrustation on the wheel and guides and in the penstock and draft tube. Periodical inspection on this point will prove well worth while in increasing the capacity.

In this connection it should be noted that the average daily head should be maintained at its maximum. In manufacturing plants that operate only a portion of the day the head will build up over night so that in the morning a maximum head is available. This head should be kept at its highest point as long as possible and not be pulled down the first thing in the morning so that thereafter throughout the day it is necessary to operate on a reduced level.

The point to be kept in mind is that hydraulic horsepower costs money just as does steam horsepower and the units of the plant and operating conditions require the same amount of attention to give the same results. Constant watchfulness is the keynote of success in either type of plant.

Alcohol derived from molasses is being tried out in Cuba as a fuel for automobiles, 13,000 gal. a day being produced during the month of August. It is denatured by a special formula which avoids the naphthalene residue and has a special coloring to distinguish it from that denatured by the usual method. About 2½ gal. of low grade molasses is required for 1 gal. of alcohol, but it is thought that it may be possible to use the bagasse or refuse cane for the raw material of the process. With molasses at 2 cents a gallon, it is claimed that alcohol can be produced to sell for 20 cents a gallon.

It is found that unless some addition is made of substances having a lubricating value, there is a tendency for the motor to rust. Also it is necessary to adjust the needle of the carburetor or change the opening through the nozzle, and to coat the float with wax which will not be dissolved by alcohol. Prices on the street for the motor spirits are 27 to 30 cents in Cuba as compared to 45 cents for gasoline. The matter of mileage per gallon is still a question.

In the study of the ignition of coal-dust clouds in open air, being conducted at the Experimental Mine of the Bureau of Mines, Bruceton, Pa., tests were recently made with pulverized Pittsburgh coal and with pulverized Colorado lignite. In some of these tests flame extended 45 ft. into clouds that were 50 ft. long, the lignite dust cloud making a larger flame than Pittsburgh coal dust. An attempt will be made to get a greater length of flame with an increased length of dust cloud.

Recent Developments in Superpower for Indiana*

AUTHORITY GRANTED INDIANA ELECTRIC CORPORATION TO CONSOLIDATE SEVEN UTILITY COMPANIES BRINGS FORTH SUGGESTIONS FOR PLANS OF PROCEDURE. BY FREDERICK L. RAY

IF WE can devise plans to use less coal per kilowatt-hour generated, then we are fuel conservationists; therefore, anything that is being done to harness the water power of the state and to build superpower stations or to organize super-utility companies will be to the interest of our people. We must use fuel for the generation of power, and we cannot restrict the use of power to save fuel but rather we must use more power every year; therefore, our problem is to use less fuel per unit of power generated.

This is to be accomplished in two ways.

First: By building large power stations or superpower stations as we now term a large station, in which electricity can be generated at a minimum cost for fuel.

Second: There must be enough copper in the transmission lines so that the transmission loss will be a minimum, for every unit of power lost in transmission means so many pounds of coal lost.

In justice to posterity, when a superpower generating and transmission system such as that planned for Indiana is built from the very start, plans should be laid for a great loop system of transmission so that the whole central part of the state from east to west and from the Wabash River on the north to at least 75 miles south of Indianapolis, would be covered by a network of primary and secondary transmission lines that would give this section cheap and reliable power.

The greatest economies that are now being made are by the electric utility companies and their failure to attain to the highest possible success is due to the restrictive measures that have prevented their expansion.

If given the greatest possible latitude in rates so that there would be an attractive return on investment, they would be able to secure capital with which equipment could be purchased that would reduce the coal consumption from 5 lb. per kw.-hr. to less than 2 lb. per kw.-hr.

The development of our state would be benefited by this reduction in fuel consumption in three ways: First, Lower rates of power; second, progressive and reliable utilities; third, the conservation of fuel.

There should be a broader policy of legislation, regulation and financing that would give encouragement to the expansion of our public utilities so that they would be able to give cheap power with the consumption of the least amount of fuel.

To advance these plans to a practical working basis, it may be necessary to consolidate a large number of the present companies and form super-utility companies and, if necessary, this should be done in the interest of all the people.

This project is so big and so far reaching that ultimately one of three things will be done:

First: There will be consolidation of all utilities into a super-utility, serving all of this superpower zone.

Second: The state will build and operate the high tension transmission lines charging the distributing companies a price per kilowatt-hour for the use of the lines, the power to be generated in superpower stations by private corporations and sold to the distributing companies.

Third: This plan is to generate by private corporation in superpower stations and sell at the plant to private corporations, who would distribute on individual transmission lines, connecting together such distributing system as now exists.

The third plan is about to be tried at this time, for the Public Service Commission of Indiana, on Jan. 27, 1922, gave authority to the Indiana Electric Corporation to consolidate seven utility companies and will, no doubt, within the near future, grant permission to build a superpower plant on the Wabash River, where power will be generated and distributed to the seven consolidated companies. This plan cannot be the success from the fuel conservation point of view that the second plan would be; for the transmission would be built, no doubt, on the basis of the Kelvin Law or an approximation thereto, which would provide for a certain loss in transmission which would, no doubt, be a much greater loss than if the state built and operated the lines, having in mind the transmission of power with the least possible consistent power loss.

In the design and building of such a system of transmission, the conservation of fuel should have due consideration, which is not likely to happen if the line is built on Plan I or III; for under Plan I or III there will be the least amount of copper put in the lines that it is practical to use and avoid serious power losses. The management of such state lines of transmission of power should be in the hands of a board of directors appointed for life, by the Governor, and all vacancies on this board by resignation or death will be filled by the Governor. The management of such a transmission line, in the hands of the board appointed this way, would give assurance to the public that its interest would be protected.

The interconnection of existing plants with a system of superpower stations will increase the economics of these stations by taking their peak loads, thereby giving a better load factor. As these plans become inefficient and obsolete, they will be discarded and the loads taken up by the superpower system. In this way the market for the superpower system will be provided.

The transmission lines will be just as reliable as the superpower stations. This is accomplished through the loop system and the division of circuit, to get a duplex, triplex, or quadruplex system as the capacity demands. There would be enough capacity in such a system so that the loss of one of these lines would not interfere with the service.

My conclusion is that it will be perfectly safe to assume that the average steam consumption for central Indiana is not less than 45 lb. per kw.-hr. With a large turbine of say 35,000 kw., the steam consumption can be cut down to less than 15 lb. per kw.-hr.

*From a paper read before the N. A. S. E., at Anderson, Ind.

Factory Tests of Turbines and Generators

TO SUPPLY the increasing demand for turbine-driven sets of ½ to 900 kw., Westinghouse Elec. & Mfg. Co. has recently erected a one-story plant in South Philadelphia, a feature of which is the testing department. A space of 6700 sq. ft. is used for this work, allowing for test of 4 units, condensing, of 100 to 500 kw. output at once, also three 15-kw. sets, four of 10 kw., four of 5 kw. and five of 1 kw. or smaller. For the units of 15 kw. and smaller tables with test plates are provided, and for the larger units plates grouted into the concrete floor.

Eight turbines can also be tested by means of water brakes, of which three sizes giving range from 2 to 1200 hp. are used. These tests are usually run non-condensing.

Piping for live steam, exhaust and water are carried in tunnels below the floor, steam being available at 200 lb. pressure and 100 deg. superheat. All piping is arranged and supplied with valves to give maximum flexibility of connection and use.

On the electrical side tests can be made of generators up to 800 kw., those from 50 to 800 kw. being tested in one section, and from ½ to 62½ kw. in another. As most runs are made for short periods, no saving of energy generated has been attempted, the load being grid resistances hung overhead from the crane girders and having switches so that load may be adjusted as required. The grids take current at 110 or 220 v., transformers being provided to step down from 1100 or 2200 v.

A switchboard with six main and four auxiliary panels provide for handling direct current up to 3000 amp. on a circuit and for generators, exciters and transformers for a.c. tests. Grid circuits have on one leg a 500-amp. contactor with push button control or controlling the rack switches to regulate load gradually or quickly as required. Instrument tables are placed under the grids near the switchboard so that the tester has ready control of load conditions while taking readings.

Features of the test plant are: Few and short temporary connections; grid load can be distributed or concentrated; load readily transferred between machines; whole load quickly thrown on or off by remote control push buttons and contactors; tester has complete control and knowledge of load conditions.

MAIN BAY OF TESTING FLOOR

A NEW COMPASS for airplanes has been invented by Doctors Paul R. Heyl and Lyman J. Briggs of the Bureau of Standards, Department of Commerce. This compass depends on a revolving coiled wire for its action instead of a magnetic needle, the latter being too slow in its action to keep up with the rapid revolutions of a plane. Many pilots, during the war and in mail service since, have lost their lives because of losing all sense of direction from lack of a compass which would function. The staff of the Bureau has been at work on the problem for a year, and the new device is the result. It has been tested in flying and is now being put into service.

If we don't do all that we are paid to do, by and by nobody will want to pay us for what we do want to do.—FORBES.

Diesel Engines*

THE TWO CYCLE, SOLID INJECTION, ETC., LUBRICATION

THERE IS NO theoretical difference between the four-cycle (described in the March 15 issue) and the two-cycle method of developing power in an engine. The two-cycle is merely a mechanical modification by which the piston itself acts as an exhaust valve, and as soon as exhaust has occurred fresh air is blown into the cylinder from an outside source, the exhaust and suction strokes being thus eliminated. Hence but two strokes of the piston are necessary for a complete cycle, and in operation there are twice as many power strokes in a given number of revolutions, and twice as much power would be developed if each impulse were as great as for the corresponding four-cycle operation. Diagrammatically the operation of one form of two-cycle is shown in Fig. 1.

All two-cycle engines require some external means of pumping all of the scavenging air at a slight pressure ranging up to 5 or 7 lb. per sq. in. Many means are taken to do this; the underside of the engine piston is used; or a large piston is made integral with the engine piston; or as is most customary in present Diesel practice, an independent double-acting scavenging pump is driven at one end of the engine.

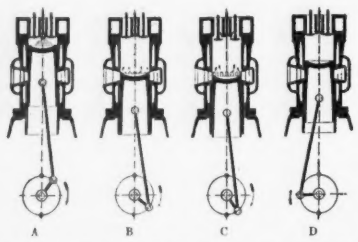
A theoretical study of these two Diesel cycles promises the following prominent advantages for the two-cycle engine:

1. Almost twice as much power in a given size cylinder.

2. Elimination of exhaust valves (and usually scavenging valves) in the cylinder head, which makes this complicated unsymmetrical casting much less vulnerable to cracking from the stresses caused by expansion from large temperature changes, as may be understood from Fig. 2. Difficulties experienced in cooling large exhaust valves to prevent warping and burning, and complicated head casting place a limit to the size of cylinders of four-cycle engines.

3. Less weight and less cost per horsepower developed.

4. More even delivery of power, because of more power impulses in a given time.



(A) Piston traveling down; all valves and ports closed; fuel injected and burnt during first part of stroke; gases expand.
(B) Piston traveling down; piston uncovers exhaust ports; burnt gases escape through exhaust ports, reducing the pressure to atmospheric.
(C) Piston traveling down; exhaust ports still uncovered; scavenging valves in head open; air under light pressure enters through scavenging valves and blows gases out of cylinder.
(D) Piston traveling up; piston covers exhaust ports; scavenging valves closed; air in cylinder is being compressed.

Fig. 1

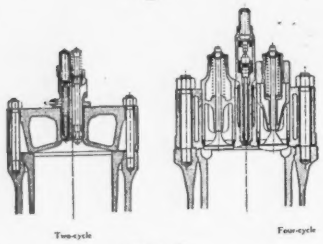


Fig. 2

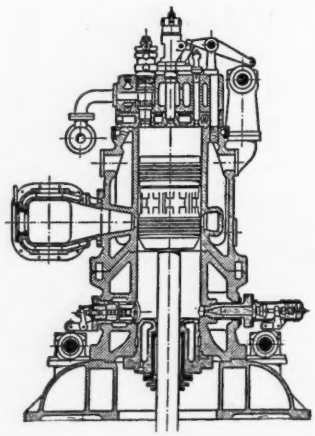


Fig. 3

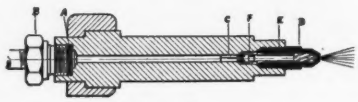


Fig. 5

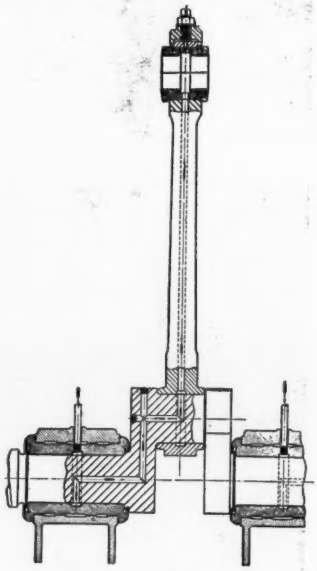


Fig. 6

FIG. 1. DIAGRAMMATIC OPERATION PRINCIPLES OF THE TWO-CYCLE DIESEL ENGINE WITH SCAVENGING VALVES. FIG. 2. COMPARISON OF CYLINDER HEAD FOR A TWO-CYCLE AND FOUR-CYCLE ENGINE; NOTICE HOW MUCH SIMPLER IS THE COOLING OF THE FORMER. FIG. 3. SECTION OF A DOUBLE-ACTING TWO-CYCLE CYLINDER WITH COMMON EXHAUST PORTS AT CENTER FOR BOTH ENDS. FIG. 5. A FUEL VALVE USED ON ONE TYPE OF "SOLID INJECTION" DIESEL ENGINE. FIG. 6. LUBRICATION OF CRANKSHAFT, CRANKPIN AND WRISTPIN BY FULL PRESSURE CIRCULATING SYSTEM

5. The higher cylinder temperatures and lack of valves make it easier to operate on very viscous grades of fuel.

On the other hand there are the following disadvantages:

1. Scavenging is not as perfect, thus the power is not doubled but about 75 per cent greater, and the fuel consumption per horsepower correspondingly higher.

2. The scavenging air pump is a large added mechanism, increasing weight and cost, and consuming about 10 per cent of the engine power.

3. The greater work done in a cylinder subjects it to a greater heat, and therefore to greater expansion stresses, and makes lubrication more difficult.

4. It is difficult to make a joint between the cylinder liner and jacket at the exhaust port which will not let water leak into the cylinder.

*Abstract of an article appearing in Lubrication, which is published by the Texas Company.

5. With scavenging ports on one side of a cylinder, and exhaust on the other, uneven expansion will cause stresses and possibly warping of the cylinder liner.

6. As the load on the connecting-rod bearing is always in one direction and never reversed by the piston momentum, as happens with four-cycle engines at the end of the exhaust stroke, bearing lubrication is much more difficult.

Double-Acting Lubrication

Another method for reducing the cost and weight per horsepower is to increase the power from each cylinder by making it double-acting, like almost all steam engines; that is, to provide a crosshead and pass the piston rod through a stuffing box as is done in Fig. 3, so that a power cycle can be gotten from each side of the piston. Such a construction is particularly promising for two-cycle engines because one set of exhaust ports can be used for both sides of the piston. On the other hand, piston cooling particularly, and cylinder lubrication, as well as the piston rod packing and its lubrication, are very difficult matters to handle. When they are finally mastered double-acting engines are certain to be a prominent type.

"Mechanical" or Airless Fuel Injection

In order to eliminate the cost, complication and even danger of the high pressure air system required by the first successful Diesel engines, a great deal of development has been under way for several years, toward injecting the liquid fuel without air. The advantages of such a simplification of design are particularly noticeable for very small engines where the use of air injection would be almost impossible because of cost and the lack of care given these units.

The Semi- and the Super-Diesel

For several years a large number of small so-called "Semi-Diesel" engines have been marketed, in which the liquid fuel is injected onto a hot surface within the combustion chamber, which sprays, "cracks" and ignites the fuel. These engines are more correctly termed "Surface Ignition" engines, because compression of the free air in the cylinder is not sufficient to supply the temperature required for ignition without the hot surfaces. Starting thus requires heating the surface as a preliminary step. After the engine has started, the temperature of the ignition surface is maintained by the heat of combustion, since water cooling is not used for this part and it naturally runs hot whether of the "Hot-bulb" or "Hot-plate" type.

Another type of small engine in which, however, ignition is not secured by hot surfaces, is the Hvid engine sometimes spoken of as the "Super-Diesel." Many of these engines are in regular use on American farms, in units as small as 1½ hp. The fuel valve cage of this engine terminates in a small steel cup, as may be seen in Fig. 4, into which a mixture of air (from passages F and G) and fuel (from metering pin E and orifice D) is drawn during the suction stroke of the piston. Near the end of the compression stroke the highly heated air which rushes into the cup through the holes H, volatilizes or cracks enough fuel to start combustion, which forces the rest of the oil out through the holes H, much as would an air spray. It is claimed that these engines can be started cold, and while they thus show points of superiority over the Semi-Diesel they also lack flexibility as to speed.

The "Solid Injection" Diesel

The two methods just described, of handling fuel without air injection, may be looked upon as stepping-stones toward the elimination of air injection by forcing the oil directly into the cylinder at the time of combustion.

In general, two systems are used for solid injection; in one, oil is pumped to the fuel valves at a pressure of 4000 to 5000 lb. per sq. in., and is admitted when the valve is opened by suitable cams. The quantity of fuel sprayed varies with the time the valve is open and thus with both the cam profile and engine speed. The second system makes use of a separate plunger pump for each cylinder, which meters out the required quantity of fuel and delivers it at whatever pressure is necessary.

Figure 5 shows a type of fuel valve used on some solid injection engines of the second type, with the spiral passages D used to secure a turbulent, quickly spraying stream, and the heavily spring loaded check valve, C, which prevents fuel remaining in the fuel line from "dribbling" in after the quantity desired has been forced through. It appears that the oil stream passing through a spray valve continues like a straight needle

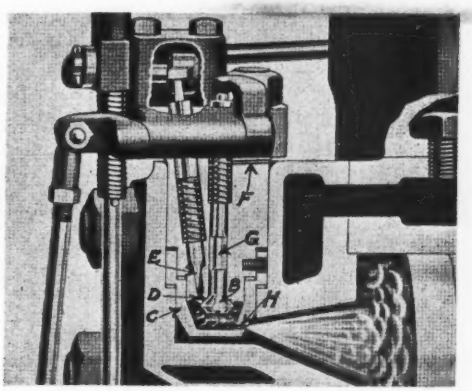


FIG. 4. SECTION OF PART OF A SMALL HVID ENGINE CYLINDER SHOWING DETAILS OF FUEL CUP AND VALVE

for a little distance before it breaks up into the desired spray. This spray when once formed is so fine that it floats away when in the open like a cloud of smoke and can be easily ignited, though the solid needle can be ignited only with great difficulty.

Lubrication of Diesel Engines

The superiority of circulating force-feed lubrication to all crankshaft bearings is now so well appreciated that it is the rule rather than the exception. Nevertheless, there are many old time operators who object to the enclosed crankcase construction always used with this lubricating system, because they cannot feel the bearings and know if they are running hot. They overlook the fact that most of the bearing troubles experienced in the past have been where wick or some other form of drip lubrication was used, and that bearing trouble is practically unknown with the pressure system if the clearances are correct, and if the oil flow is not

interrupted. Of course, there is a possibility that excessive clearance may develop in one bearing which will deprive the other bearings of their oil supply, but this can be detected by a drop in the oil pressure. On some engines oil is led to the crankpin and even the wrist pins under pressure by means of passages drilled through the crankshaft from the main bearings to the crankpins (Fig. 6.), as is done in airplane engines. It is more customary, however, to lubricate the crankpins by collecting the oil leaking from the main bearings, into rings attached to the crank-cheek.

Since one of the characteristics of the pressure system is the circulation of much more oil than necessary for lubrication alone in order to cool the bearings somewhat, excess oil is thrown from the rotating parts and sprays around in such a way that a tightly enclosed crankcase is very desirable to prevent wastage of oil. Another and even more important reason for tightly enclosed crankcases is to keep dust and dirt from entering the lubricating system where they would form an abrasive and cause rapid bearing wear. As a precaution, filters are always used between the oil pump and bearings, preferably of the duplex type, which allows one to be cleaned at a time without interfering with the flow of oil. Screens should be used also between the cranksump and the oil pump to strain out any foreign matter such as rags, etc., which would interfere with the pump action. Cotton waste should never be used about any engine with a circulating lubricating system because it is so easy for small pieces to get into the oiling system, but, unfortunately, this is common practice. A tank should always be placed in the system to allow very fine foreign matter to settle out, which otherwise would pass through the filters, or used as a reserve oil tank.

At all events drains should be provided not only for drawing off the sediment, but also any water which has settled out. All possible means must be taken to prevent water, especially salt water, from entering or remaining in the lubricating oil.

Requirements of Lubricating Oil

For practical reasons it is desirable to use the same oil for all parts of an engine—cylinders and bearings. but little need be said about the type of oil to be used, in spite of all the elaborate specifications that have so frequently been published. It is assumed, of course, that no operator would be so "pennywise and pound foolish" as to jeopardize the life of an engine costing nearly $100 per horsepower, by using an oil not known to be well refined and of the first quality. Unfortunately, the degree of refining cannot well be judged by those who operate the engines, and they must accordingly rely on the reputation of the refiner for this. In addition, bear in mind that:

1. The oil must, of course, not congeal at any temperature to which it will be exposed in service.

2. The oil must be viscous enough to form a fair piston seal but not so viscous as to cause undue fluid in the bearing.

3. It must spread readily over the cylinder walls, and not remain in streaks or patches.

4. It must not form bad emulsions as it is frequently mixed inadvertently with a little water in service, sometimes, even salt water.

5. When exposed to the intense heat of combustion, which will decompose any oil, it must leave a minimum of carbon when disintegrated, and the carbon must not be gummy.

6. It must not be so volatile that an undue quantity will be necessary to maintain a good film on the cylinder walls.

7. It must not react and thicken with sulphur from the fuel.

Self-Contained Lighting Units Popular Abroad

Lighting sets for houses, estates and clubs are popular abroad, is the statement made in Commerce Reports by the Bureau of Foreign and Domestic Commerce. Direct-connected units are more popular than belted, and hand-started than automatic, on account of the simplicity and ease of keeping in repair. Air-cooled engines have given satisfaction, but in some sections the water-cooled are preferred because of the greater certainty of cooling in a hot climate.

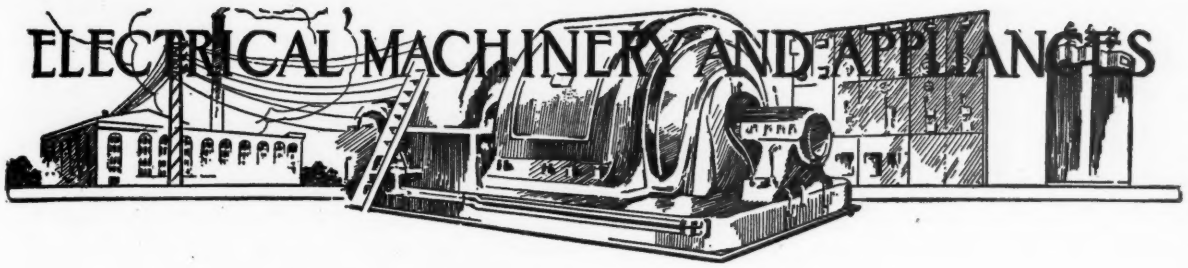
Capacities wanted range from ¾ kw. up to 5 kw. with some demand for ½ kw. and for sizes larger than 5 kw. The usual voltage is 32; but in case of large estates and for moving picture houses where no battery is used, 110 v. is asked for. Proper maintenance of a battery is difficult to secure in remote districts, which works to create a demand for units without battery equipment.

Shipment must be made in cases of size and weight that can be transported to out-of-the-way places, and should be somewhat smaller than is usual for domestic shipments. Care should be taken that the units are adapted to the service and conditions to be met, for where only kerosene is available for fuel, a gasoline engine will be unsatisfactory, and if 32-v. lamps cannot be secured on the market where the unit is working, it will be a source of irritation.

In some countries, where there are a number of small streams flowing through plantations, there is a demand for small waterwheel-driven units, or for generators to belt to a wheel already in use.

Inactivity in the markets for rubber, jute, tea, coffee and sugar has cut down the demand for plantations just now; but as business revives, this demand will increase. General machinery import houses and electrical dealers in foreign countries are the usual channels for securing trade.

The past work on the float-and-sink method of cleaning coal, conducted at the Northwest Experiment Station of the Bureau of Mines, Seattle, Wash., has resulted in the development of an efficient large-sized machine for making these tests. This machine has been used in studying the washability of coal, in controlling the washing operation, and for measuring the efficiency of the individual coal-washing machines. In using this machine for future studies, there is a possibility that it will be developed even to a more efficient point. This machine, however, does not give satisfactory results using fine sizes of coal. Work is being planned in which the limitations of the float-and-sink method on fine sizes will be determined. It is hoped that the float-and-sink machine can be adapted to washery control in the coal washeries of the State of Washington.



Equipment for Battery Charging

SOLVING RHEOSTAT PROBLEMS ARISING IN CHARGING STORAGE BATTERIES. BY H. M. PHILLIPS

APPARATUS used in connection with charging storage batteries may be very simple or extremely complicated, depending upon the service required and the idiosyncracies of the designer. The present article deals only with the rheostat problems arising in charging from a 115-v. direct current circuit.

As the maximum charging current varies with the size of the battery from about 1/10 amp. up to several hundred amperes, the rheostat problem is not always an easy one.

A lamp bank, of more or less elaborate construction, can usually be made up from material on hand, and is perhaps the best method of charging very small batteries. To obtain very small currents, or close adjustments, two or more lamps may be connected in series; with several lamps in series, adjustments may be obtained by removing a lamp and inserting a fuse plug in its place. The connections of lamps and battery are illustrated in Fig. 1. When using a lamp bank it is frequently permissible to omit the ammeter, a sufficiently accurate estimate of current being obtainable from the number of lamps in circuit. A rough estimate may be obtained by using the amount of current per lamp which would be delivered at normal voltage (watts ÷ volts). The actual voltage on the lamps is lower than the line voltage by the amount taken by the battery and assuming that the lamp resistance remains unchanged, a proportionate reduction may be made in the current originally estimated. There is also a considerable change in the resistance of the lamps which will be lowered for tungsten filaments and increased for carbons; for a rough approximation, the previous correction may be increased or diminished by 50 per cent.

EFFECTS OF ACCIDENTAL GROUNDS ON LINE

IN A FEW instances it may be desirable to leave the battery on a continuous charge, in which case a very small current will probably be sufficient. If connected as shown in Fig. 2, with an accidental ground on the line at "G," there will be 115 v. between the battery line "A" and ground which is likely to prove too much for the insulation and give disagreeable shocks or dangerous short circuits. Conditions may be improved by connecting as shown in Fig. 3, in which case there can be but little over half the line voltage between the battery line and ground and in case of a ground the resulting current is limited by the lamps in series. The existence of a ground current will also be indicated by the difference in brilliancy of the lamps on the two sides of the battery. Even this connection is, however, rather a severe strain on the insulation of an ordinary battery circuit and the apparatus connected to it.

If it appears desirable, small resistance units of the desired resistance and current carrying capacity may be purchased at a moderate cost, or a charging rheostat designed in accordance with principles given below may be substituted for the lamp bank, but the fact that the latter gives a visible indication of current

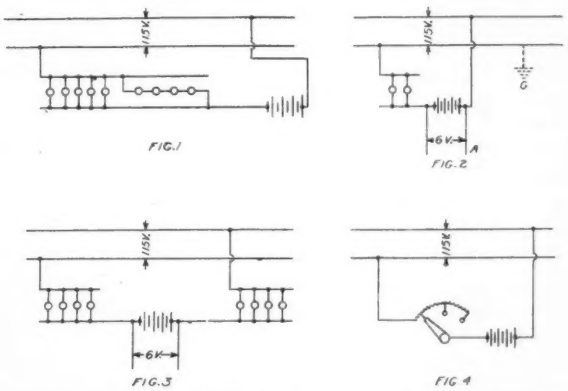


FIG. 1. CHARGING BATTERY BY MEANS OF A LAMP BANK
FIG. 2. ACCIDENTAL GROUND ON LINE MAY MAKE THIS CONNECTION UNDESIRABLE FOR CONTINUOUS CHARGING
FIG. 3. IMPROVEMENT UPON CONNECTION SHOWN IN FIG. 2
FIG. 4. TYPE OF RHEOSTAT SUITABLE FOR CHARGING A 100 AMP.-HR. BATTERY

flowing is an advantage and it will in no case be damaged by excessive currents or careless handling; in fact, it is less likely to give trouble than the ordinary rheostat.

Charging low voltage batteries by either lamp bank or rheostat is, of course, very inefficient in regard to the use of current; the small motor generator on the other hand will not usually exceed an efficiency of 70 per cent, requires some attendance and maintenance, and is comparatively high in first cost. It is only advisable to use one when the cost of current is high or is used almost continuously. Two or more low voltage batteries of the same capacity may be connected in series and charged with the same expenditure of time and current as one; to maintain the same current a larger number of lamps must be used on account of

the lower voltage on the lamp bank and as the correction for change of lamp resistance is of doubtful accuracy, an ammeter in circuit becomes more necessary as the charging voltage increases. As the charging voltage becomes higher, the increase in the number of lamps required renders the lamp bank less desirable until a point is reached where it is advisable to install a rheostat. If any considerable amperage is necessary, even at low voltage, the same condition holds; the lamp bank is therefore limited to a rather small field.

Rheostats

Whether the engineer proposes to build his own charging rheostat or to purchase it from a manufacturer (the latter is likely to prove the cheaper and more satisfactory method) satisfactory results at a minimum cost generally demand more careful study than the subject usually receives. If a manufacturer is requested to bid on a rheostat for charging a lead cell battery of given voltage and ampere-hour capacity he may, without asking further particulars, estimate on one that will give fairly satisfactory service under the usual operating conditions; a competitor may figure still more closely, or on a rheostat of greater capacity and flexibility; neither may meet all the requirements that will arise in the actual operation. The manufacturer should be given the fullest possible information in regard to the actual currents and resistances desired; if a selection is made from manufacturers' catalogs, careful study should be made of the data contained therein and additional information obtained if that given is in any way incomplete. The points to be covered are illustrated by the following examples:

The ampere-hour rating of a battery, unless otherwise stated, is based upon an 8-hr. rate of discharge; that is to say, a 100-amp.-hr. battery will deliver 12.5 amp. for 8 hr. In charging, it is considered good practice to begin with a 5-hr. rate for one hour, reduce to an 8-hr. rate for 6 hr. and continue to charge at a 12-hr. rate until the charge is completed. For a 100-amp.-hr. battery these figures would give 20, 12.5 and 8.3 amp. Each cell will require about 2 v. at the beginning of the charge and 2.5 v. at the end, the rise being rather rapid at first, continuing to increase more slowly during the greater part of the charge and rising more abruptly towards the end. The cheapest rheostat to charge a 100-amp.-hr. battery would therefore consist of three sections, one of which would be left permanently in circuit as shown in Fig. 4. To avoid undue sparking on the contacts it is desirable to increase the number of steps or to substitute two single-pole switches for the ordinary sliding contact of the rheostat arm. The first step should therefore have a resistance of $\frac{115-6}{20} = 5.45$ ohms and a capacity of 20 amp., the second $\frac{115-7}{12.5} - 5.45 = 3.19$ ohms and 12.5 amp.; the third $\frac{115-7}{8.3} - 8.64 = 4.37$ ohms and 8.3 amp. In some cases a rheostat built along these lines would be desirable, limiting the maximum current to 20 amp., but if very rapid charging, with some sacrifice of efficiency and battery life, is desired, the starting current may be carried as high as the 2-hr. discharge rate (50 amp.) in which case the resistance of the first step would be 2.18 ohms with 50-amp. capacity which, on account of the greater wattage, would call for a heavier and more expensive rheostat. The same minimum current would probably be desirable, making the total resistance the same as before and a greater number of steps would be needed to obtain the proper current at different times during the charge. In some cases it may be advantageous to be able to reduce the current to a much lower value than the 12-hr. rate at the end of the charge, in which case the total resistance would have to be increased and still more steps added to get satisfactory current regulation.

Charging Batteries in Series

If ten 6-v. batteries were to be connected in series on the rheostat as originally designed, the maximum current obtainable would be $\frac{115-60}{5.45} = 10.1$ amp. and the total resistance of the three steps required to give a final charge of 8.3 amp. would be $\frac{115-67.5}{8.3} = 5.72$ ohms. The change in battery voltage from a minimum of 2 to a value of 2.25 shortly before the charge is completed has an insignificant effect with the 6-v. battery alone, but becomes a factor of considerable importance with the higher voltage; if the current is to be kept even approximately constant for any length of time, there must be a considerable number of steps on the rheostat by which small amounts of resistance may be cut out as the battery voltage increases.

A rheostat designed for charging ten 6-v. batteries in series, or a 60-v. battery, might have a minimum resistance of $\frac{115-60}{20} = 2.75$ ohms with a capacity of 20 amp., a total resistance of 5.72 ohms with a capacity of 8 amp. on the final step, and half a dozen or more intermediate steps with capacities graduated between 20 and 8 amp. It is possible, and not unlikely, that at some time the occasion might arise where a 6-v. battery or even a single cell required charging. In the latter case the minimum obtainable current at the beginning of the charge would be $\frac{115-2}{5.72} = 19.7$ amp. which would quickly burn out the section designed for only 8 amp. To make the rheostat available for this service, it would be necessary to bring the capacity of all of the sections up to 20 amp. This alone would be rather severe on the battery and it would be well to add enough steps of lesser capacity to cut the current down to 8 amp. while charging a single cell.

It may also happen that the single cell, or low voltage battery is of greater capacity than the one which has just been considered, or, what is more probable, that the operator decides to start the charge at a high amperage; on a single cell he can readily get any cur-

rent up to $\frac{115-2}{2.75} = 41.1$ amp., but of course is likely to burn out the rheostat in a short time if he goes above 20 amp. To make the rheostat safe under all conditions the first step should have a capacity of 41 amp. and each succeeding step proportioned to carry the maximum current that it can deliver to a single cell, or what is practically the same thing on a short circuited battery. As the heat generated in the rheostat varies as the square of the current, this last change would add very materially to the size and cost of the rheostat; with the rheostat designed for a 6 or even 12-v. battery the change would be hardly perceptible, while with the rheostat designed for charging more than the 30 cells already considered, the cost would soon become prohibitive.

The carbon rheostat, where changes in resistance are obtained by varying the pressure upon carbon discs or plates carried in a suitable container, is worthy of consideration as a battery charger. Between maximum and minimum limits the exact current desired is readily obtainable; the pressure being adjusted by means of a screw and hand-wheel, the rheostat has practically an infinite number of steps. On the other hand, the position of the hand-wheel gives little if any indication of the amount of resistance in circuit, leaving the operator entirely dependent upon the ammeter. With the ordinary type, the experienced operator knows at just what point on the rheostat the proper current should be obtained, which saves considerable time, serves as a rough check on the accuracy of the ammeter, and in case of emergency, enables the operator to charge batteries if the ammeter is out of commission.

It is not well to ask a single rheostat to provide too great a variety of operating conditions in the way of cells of different capacities and varying numbers of cells in series; it may be both better and cheaper to use two or more rheostats. A clear insight into what is really necessary, what is sufficiently desirable to justify the expenditure of an additional first cost or "overhead," and what can be omitted without fear of future trouble, is the principal attribute of the first class engineer. A man of very ordinary engineering ability and no regard for cost can order apparatus of more than ample capacity and provide all of the latest safety and automatic devices that the salesman may bring forward; perhaps the various automatic devices will require considerable time on the part of a skilled electrician to keep them in order, but aside from that he will probably have a very good outfit, although a more satisfactory one might have been obtained for far less money. If he is over-inclined to economy, he may secure a very cheap outfit that will cause loss of time whenever it is used, will damage the batteries through lack of proper current control, will be laid up for repairs at the time that it is most needed and will have to be replaced after comparatively short service either on account of a total breakdown or some slight change in service requirements which it is unable to meet.

Safety Features on High Voltage Transmission Lines*

A Discussion of Methods and Practices Which Make for Greater Protection and Safety in High Tension Work. By C. O. VonDannenberg

THE FOLLOWING notes cover a brief review of certain features in high voltage electrical installations to which it is believed particular consideration and attention should be given in order to attain a maximum degree of protection and safety.

It is not intended to discuss the subject from a technical standpoint but to state some of the features of greatest importance in a simple way and where possible to illustrate by definite examples, conditions as they exist in actual practice.

As a general statement it may be said that fewer accidents result in the operation of high voltage than in low voltage equipment, that is, for operation at 600 v. or less. This statement is, however, somewhat misleading for the following reasons:

1. The number of persons handling high voltage equipment is much smaller, as low voltage equipment is in far greater use.
2. High voltage equipment is much less accessible and is usually placed out of reach.
3. The persons handling high voltage equipment are usually of greater intelligence.
4. The knowledge that a high voltage exists tends to lead to greater care in handling equipment.

Line Structures

For transmission lines, the strength of the structure deserves the most serious consideration. The construction of wood pole lines is more or less standardized; but with steel pole and tower lines, certain modified designs with members cut down to the lightest possible section have given much trouble.

In reference to the strength of the conductors, various engineering societies have endeavored to standardize on certain definite loadings, and it is to be strongly recommended that no conductor have a tensile strength of less than twice the estimated strain to which it is to be subjected.

Where wood pole lines are in use particular attention should be given to the following: (1) Climbing space; (2) buck arms; (3) pole steps.

In the matter of climbing space, valuable suggestions and recommendations have been made by the N. E. L. A. and the Bureau of Standards; but it may be said in general that if 6 in. were added to the pole spacings recommended by the two foregoing authorities, there would be considerably less trouble due to the confined limits in which a lineman is forced to work. Every effort should be made to arrange the various conductors of a distribution system so that they shall maintain as far as possible the same relative location on all poles and other structures. This feature is important in order that linemen and other workers can be shifted from one district to another and be able to handle work on line connections with the least likelihood of making a mistake.

Work on poles would be greatly facilitated if buck

*Abstract of paper read before the American Society of Safety Engineers.

arms, commonly used on corner poles, could be eliminated as far as possible, or, in other words, at any corner pole where there was a great concentration of lines it would be better to continue the circuits for another span in each direction and make the inter-connections between circuits aerially rather than to attempt to do so on a corner pole where the crowded condition due to the addition of buck arms would make it dangerous to work.

Another point which deserves attention is the matter of providing a sufficient number of pole steps. Considerable trouble and many accidents have resulted in not providing them at sufficient points, particularly corner poles, poles on which certain lighting fixtures are attached and poles on which switches or other special fixtures are erected. Poles located at such points are usually climbed oftener than other poles, which results in the cutting up of the surface and in time makes them very difficult and dangerous to climb. The addition of steps, therefore, will undoubtedly help materially to relieve this condition. The tendency to omit steps from poles is obviously more prevalent among the smaller companies than among the larger ones that have made every effort to standardize their methods of construction and to make their installations as safe as possible.

Line Disconnecting Switches

In connection with the operation of transmission lines, particularly on circuits of great length, it is usually necessary to provide means for separating them into sections at various points. In the past, it has been common practice to install ordinary disconnecting switches operated by a portable hook stick. We have preferred to install a switch of the mechanically operated type wherever possible.

With the ordinary type of disconnecting switch, it is necessary for the patrolman to climb to a point some distance from the ground and then operate the switch by means of a hook stick. With the mechanically operated type, the operating handles may be placed at a convenient level close to the ground.

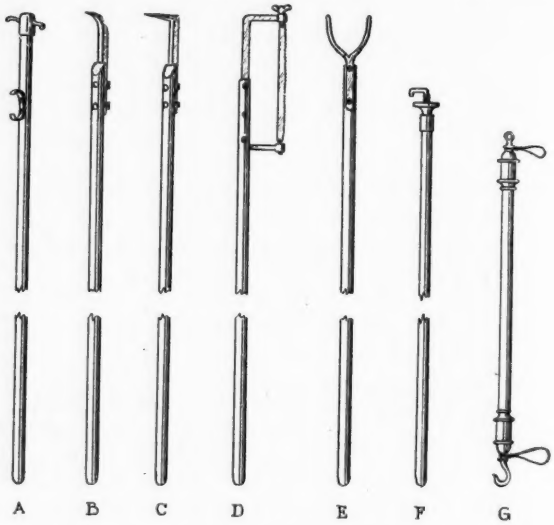
To the operating man, the far greater safety in operating the latter type of switch is particularly apparent, especially when it becomes necessary to do any switching at night, as there is definite assurance of the safety of the operator sent to do the work.

Grounding

Many accidents have resulted from carelessness in not grounding effectively metal structures carrying high tension conductors. In the case of a transmission tower line carrying two circuits, it is usually the case that one circuit is carrying load when the other circuit is being worked on, and in such cases high potentials to ground may exist. All danger can be eliminated by suitably grounding conductors on the circuit being worked on, but unfortunately the methods used have at times been very ineffective. For many years it was considered sufficient simply to throw a chain over the conductors of the dead circuit at one or more points of the section being worked on. In this connection it may be stated that the only safe ground is one that makes an absolute, permanent and positive connection with the line conductors and with the tower. This condition may be obtained in the case of the transmission conductor by the use of a flexible conductor having its ends equipped with clamps to allow a permanent and positive connection to be made to the tower and to the conductors. The Johnson clamp, as referred to hereafter, may be used in connection with line conductors and a clamp similar to that used in meter testing work for connection to the steelwork of the tower.

Telephone Equipment for High Tension Lines

In transmission line work, a great deal of trouble and many accidents have occurred in connection with the operation of the telephone equipment. Except in the cases where the telephone circuit is carried on a separate pole line, the telephone conductors are usually mounted on the same structure a short distance below the power conductors and are, therefore, subject to high induced potentials to the ground, depending on the load conditions of the power circuits and the condition of the power line insulation.



A Tie Stick Used for removing old tie wires
B Cotter key puller.
C " " "
D Hack Saw. Used for cutting tie wire, etc
E Forked stick. Used for handling suspension insulators
F Clamp stick. Used for handling line conductors
G Strain Insulator For insulating tackle when handling line conductors

TOOLS USED IN LIVE LINE MAINTENANCE

As a rule, the potentials to ground are of such a value that there is no definite, visible or audible indication of their presence. It is desirable, therefore, that any switching equipment in direct contact with the line conductors be so located that any accidental contact may be absolutely prevented. By the use of insulating transformers and drainage coils, it has been possible to do away with the use of insulated platforms, which are not at all desirable from an operating standpoint.

Working on Live Lines

In the earlier days of high-tension systems, work on live lines was practically limited to 2300 v. or less, and even then many accidents and fatalities resulted; but as the slogan of the operating man became that of continuity of service, every effort has been made to do repair or other work with a minimum amount of interruption to service. The use of rubber gloves was resorted to,

but unfortunately these were first used without suitable protective coverings and as a result many fatalities occurred from too much dependence being placed on them. In general, it is not advisable to use rubber gloves under any condition of working without having them provided with a suitable leather or buckskin covering which will protect effectively against any ordinary wear.

A further step has been made in requiring a lineman to wear rubber boots when working on live lines, particularly in wet weather, as many fatalities and accidents have resulted from contact of some other portion of the worker's body with a live conductor even though he was wearing rubber gloves.

Insulating shields, consisting of heavy rubber coverings are being used for protection; but, unfortunately, when working among lines that are rather closely placed they are rather bulky for use. Their use, however, is to be recommended wherever possible.

Under the usual conditions of operation, work on live lines has generally been limited until quite recently to voltages not exceeding 2300 or 4000 v. The increased desirability, however, for continuous operation has caused considerable effort and study to be made to overcome the necessity of requiring a circuit to be shut down when it was necessary to do any work. The necessity for working on live lines is particularly important in connection with transmission circuits, which supply energy for large communities and large manufacturing industries, where an interruption is of very great importance.

In this connection particular credit should be given to T. F. Johnson, Jr., of Atlanta, Ga., who has developed a very complete line of tools, some of which are shown in the accompanying illustration, which make it possible to work on live transmission lines and other circuits with complete safety and with the assurance that the work can be successfully and reliably done.

Finding Trouble in Cables

EXPLORING COIL USED TO LOCATE GROUND IN CABLE. BY J. B. DILLON

TO ENTER into the theory of the Varley loop test, or the theory of the exploring coil in this article, might seem superfluous, because anyone interested in the theory can find that in text books; but to mention how the Varley test and an exploring coil helped the writer to clear trouble in a large, lead-armored, aerial cable may be of interest. Being in the city where the cable trouble existed, I was asked to help the local folks to find their trouble. It was readily found that all conductors were crossed and grounded, the local people having tried for two days to find the trouble, and, as is usual in such cases, the condition grows hourly worse.

The cable was 4900 ft. long and hanging on 45-ft. poles. Of course, I thought of my old love first, and that was the Wheatstone galvanometer, but, strange to relate, she failed me quite a lot, something she seldom does if properly handled. The failure was that no matter how many efforts I made to burn or freeze the trouble, I was thwarted, due to water in the cable, and the nearest I could come to a conclusion was that the trouble was between one foot and 396 ft. from where my galvanometer was attached. To make the case plain, the cable strand normally measured one ohm to each 396 ft. and my Varley varied between one ohm and a fraction, but to get the proper fraction it was necessary to freeze the trouble and, as related, I could not.

I would not sanction the cutting of the cable, and this should never be done, only as a last resort.

"Have you anyone here that can ride the cable for about 400 ft.?" I asked.

There was nobody willing to tackle it, the plain truth being that they had no facilities for doing so, but I had to find the "spot" or leave them in distress.

If I could have found a rider, it is reasonable to suppose that by placing a heavy voltage there would have been sufficient heat at the trouble to have made its location known.

Going to the telephone, I called up a top notch cable wiper, explained the situation and told him to jump in an automobile and hurry over with his exploring coil. Ten minutes after the man had attached the vibrating current to the end of the cable where I had tested from, he had found the bad spot, just 250 ft. from the office end. The trouble was due to a flaw in the armor giving way and a recent rain eked it.

Do I think the trouble could have been found with the exploring coil without help from a galvanometer?

Most assuredly. The help that a galvanometer can give in cases like the one under narration is that it gives the coil artist such direction as will minimize the distance he has to travel. An exploring coil is a very useful thing to have everywhere where cable is used. Yes, they are serviceable in handling soft cables.

In a recent issue of the New York Telephone Review, it is stated that with the aid of a large exploring coil they have been able to trace the routing of each of two large loaded submarine cables crossing Raritan Bay. Each cable can be located within a strip 5 ft. wide in water as deep as 50 ft.

This is of great value when it becomes necessary to pick up a cable and it dispenses with the dragging of grappling hooks. This apparatus has been used in a number of cases to facilitate locating submarine cables at crossings where dredging work is being done. In cases of buried cables of questionable routing, the cables can be easily and accurately traced by means of it, thus eliminating random digging. When the trenching machine is used in building a subway, the cutting wheel must be raised at each pipe crossing the trench line to avoid damaging either the pipe or the trencher. The induction set and amplifier locate all such crossings very accurately so that they may be staked out in advance of trenching work.

Frequently subsidiary branches in iron pipes, and occasionally sections of main subway in iron pipes are crossed by gas or water pipes or by the cables of some foreign company, and contacts exist which allow current to flow to an underground plant, endangering it by action. Such contacts are easily located by determining the intersection of the line of the pipe with the line of the cable. The contact is then cleared by digging at that point.

Perhaps many of my readers will says: "That's all right, but how are we going to locate underground

leaking water mains?'' It is stated that the Geophone, an invention of the late war for detecting underground sounds, has been used to locate leaks in buried water pipes, the results being wonderfully accurate.

I cannot vouch for the Geophone, but I know the exploring coil is the cable man's friend.

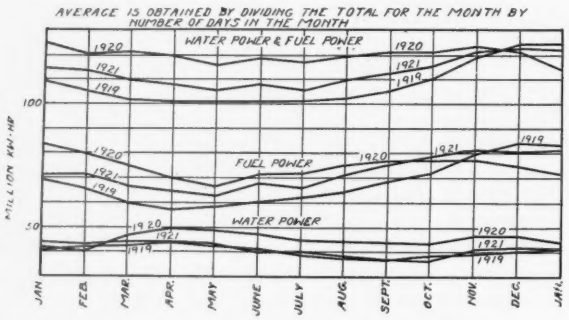
It is getting to look as if there is no safe hiding place for trouble if we know how to hunt for it.

Power Production in the United States

DURING THE month of January, 1922, there was produced in the public utility power plants of the United States 3,790,317,000 kw.-hr. of energy, according to statistics made public by the U. S. Geological Survey of the Department of the Interior. Of this quantity 2,514,018,000 kw.-hr., or about 66.4 per cent, was produced by the combustion of fuels, and 1,276,299,000, or 33.6 per cent, by water power. To produce this 2,514,018,000 kw.-hr. there was consumed 2,941,525 T. coal, 1,141,051 bbl. fuel oil, and 1,637,771,000 cu. ft. of natural gas.

The total kw.-hr. produced during the year 1921 was, by water power, 14,925,934,000 and by fuels 26,000,599,000, or a total of 40,926,533,000 kw.-hr., a reduction of about 7 per cent from 1920. The accompanying chart shows the monthly variations of production and also a comparison of the last year with the previous.

The year's consumption of fuel was 31,564,812 T. coal, 12,015,882 bbl. oil, and 23,746,290,000 cu. ft. gas.



AVERAGE DAILY PRODUCTION OF ELECTRICITY BY PUBLIC UTILITY PLANTS IN THE UNITED STATES

By converting the oil and gas consumption to the coal equivalent, the consumption per kilowatt-hour produced in 1919 is found to be 3.17 lb., in 1920, 3.00 lb. and in 1921, 2.73 lb., which indicates a marked increase in efficiency in our fuel consumption.

In this connection it is of interest to note the states leading in fuel consumption; Pennsylvania and New York lead in coal; California and Texas in oil; and Oklahoma, Ohio and California in natural gas. New York and Pennsylvania lead in the production of power from fuels and California and New York in water power.

In 1908 the Bureau of Census reported that there were 31,537 water power plants of all sizes in the United States whose aggregate water-wheel capacity was 5,356,680 hp. Of this number, 602 plants having a capacity of over 1000 hp. each, developed 3,900,000 hp.

In 1921, a survey showed that there were 3116 plants of over 100 hp. having a total capacity of 7,852,948 hp. Of this total, 79 per cent is in public utility plants and 21 per cent in manufacturing plants. This survey also shows that the minimum available hydraulic power in the country is 27,943,000 hp. and the maximum 53,905,000 hp. based on a water wheel efficiency of 75 per cent.

The available or potential water power was determined by dividing the rivers into sections of different lengths, the length depending on the slope of the channel, and the fall and flow of each section was determined. With these factors the potential power of each stream was determined on an assumed wheel efficiency of 75 per cent. Portions of streams where the slope was so small as to be incapable of profitable development were not included.

The minimum power was based on two seven-day periods of lowest flow of each year on record. The maximum flow is on the flow available 50 per cent of the time. The use of storage was not considered.

It is to be noted that it is the usual practice to install wheels of capacity much in excess of the flow used in determining the minimum power. This condition should be fully considered in estimating the potential power that may still be available at the present time.

Forty Years of Electrical Service in New York

THOMAS EDISON COMPLETED CITY'S FIRST POWER STATION IN 1882—1200 LAMPS ON THE SYSTEM

WHILE friends of Thomas A. Edison are still congratulating him on the occasion of his seventy-fifth anniversary, his associates in the electrical industry are planning additional honors for later in the year, for 1922 is not only the seventy-fifth anniversary of Mr. Edison's birth, but it is the fortieth anniversary of the completion by him of the beginning of New York's present electrical system.

On Sept. 4, 1882, New York's first central station and underground system of distribution were completed and placed in operation according to plans conceived and executed by Mr. Edison. By many, this is considered Mr. Edison's greatest contribution to mankind and the principles that were laid down in the construction of that station formed the basis of similar stations all over the world.

The original generating station occupied a reconstructed brick warehouse at 255 and 257 Pearl St., and supplied a distribution system serving only a square mile of territory. Fewer than 60 customers were supplied when the current was turned on in the afternoon of Sept. 4, 1882. Current was used only for lighting and there were but 1200 lamps in the customers' premises. Today the Edison system in New York supplies 296,560 customers and is used for lighting nine million lamps, for operating 688,000 hp. in motors and for heating purposes to the extent of 12,800 kw.

The details of this observance have not yet been decided but it is expected to arrange a commemorative celebration to take place on Sept. 4, next.

IT'S EASY to get a guy's job, but it isn't always a cinch to hold it.

Transmitting Power with Rubber Belting

CHARACTERISTICS AND CARE OF FRICTION SURFACE RUBBER BELTING. BY ANTON M. OLIVER

A FEW years ago I had the good fortune to be present during the testing of a large Lentz engine which had just been installed in a woolen mill in Austria. I still remember the accuracy with which everything was recorded. The coal was weighed, the ashes were weighed, the feed water was conducted through a meter, temperatures and pressures were carefully recorded, indicator cards were taken almost continually, etc. We knew exactly how much power we were developing and the cost of each horsepower. That is, we knew these things up to the flywheel; what happened after that we didn't know, and nobody seemed to care. The wheels were turning and it took so much power to turn them. Our tests had enabled us to produce this required power with a remarkably low steam consumption, so what more can you expect?

The transmission of power may not be as important nor as interesting a problem as the developing of it, but it is nevertheless important. It is true, we have minimized friction by the use of ball and roller bearings, we have invented paper pulleys, cast-iron pulleys, wood pulleys, steel pulleys, etc., in order to increase the co-efficient of friction, but what have we done to insure the proper installation of power transmission equipment? I have had occasion to check into this matter of belt application, pulley alinement, etc., as it is practiced in our factories, and believe that I am safe in saying that two-thirds of the belt drives could be greatly improved upon, their efficiency considerably increased. Take the matter of splicing. We all know that the splice is the weak link in a belt, that too much care cannot be used in splicing a belt and yet we are satisfied to trust inexperienced workmen, who have not the slightest understanding of power transmission, with this task. I have, on many occasions, looked on while a belt was being spliced and have marveled at the indifference of the plant management.

Savings aggregating in some cases thousands of dollars could be effected in every plant by proper belt application and care. I know of instances where belts were made to last four times longer by proper application. The right belt, applied right and and taken care of right, is the exception rather than the rule and yet it costs nothing but a little care, a little study and a little extra effort.

During the past few years, great strides have been made in the development of belts, other than leather. Rubber belting, which is often looked upon as a cheap substitute, today occupies a prominent place in many plants. The success of the so-called rubber belt is due to the development of the friction surface belt.

The manufacture of this friction surface rubber belt can be described in very few words. It is made principally of duck, which comes to the manufacturer in rolls of various widths, approximately 500 ft. long. This duck varies in weight. Most friction surface rubber belts are made of either 36, 32 or 28-oz. duck, but there are some that are made of 34, 31, 30, 26 and even 24-oz. duck. The weight of duck is ascertained by weighing a piece 42 in. wide and 36 in. long; if a piece of these dimensions weighs 28 oz., it is 28-oz. duck, if 30 oz., 30-oz. duck, etc.

In manufacturing this duck into transmission belting, it is necessary to impregnate it thoroughly with rubber suitably compounded to give a firm yet elastic bond between the plies. The duck is first dried by being passed over steam-heated rolls, then in order to secure thorough impregnation, the necessary amount of rubber, together with the fabric is run through callender rolls. Running the rolls at different speeds assures thorough permeation of the duck.

The "frictioned" duck is now taken to the cutting machine, where it is cut in widths suitable for belts of various sizes and plies. It is now ready for folding, then curing.

A friction surface belt, properly made, thoroughly impregnated with rubber "friction," is rendered absolutely waterproof and its surface remains intact throughout the life of the belt.

A rubber belt is not better than a leather belt and neither is a leather belt better than a rubber belt. Both will give trouble if misapplied and both will give good service when properly applied. There are drives where nothing but leather belting will do and again there are drives where the reverse is true. The belt manufacturer who is wise will co-operate with you to the fullest extent toward belt efficiency. He will frankly tell you if his belt is not suited for your work and he will educate your men in belt application and care.

There are certain fundamental rules, a knowledge of which is indispensable to every belt man.

The amount of power a belt will transmit depends primarily upon two factors: Belt speed and effective tension. Effective tension depends upon the difference in tension between the pulling and slack side of the belt and surface friction. Surface friction in turn depends upon ratio of tensions and angle of arc of contact.

Practically speaking, a belt will transmit proportionately more power as its speed is increased. In other words, if a given belt transmits 15 hp. when traveling at 1000 ft. per min. it will only transmit 7½ hp. when its speed is decreased to 500 ft. per min. or 30 hp. if increased to 2000 ft. per min. Actually, however, this is not exactly the case because a centrifugal force factor enters into the calculation.

The efficiency of a belt decreases, as its speed increases. At 6000 ft. per min. approximately 30 per cent of belt efficiency is lost; at 5000 ft. per min. about 21 per cent; at 4000 ft. per min. 15 per cent; at 3000 ft. per min. 10 per cent; at 2000 ft. per min. 4 per cent; at 1000 ft. per min. being 100 per cent efficient.

The power a rubber belt will transmit depends entirely upon the number of plies and the weight and quality duck of which these plies are made. Belts made of a good grade duck will transmit the following horsepower, per ply per inch of width, at 1000 ft. per min. and 180 deg. arc of contact.

	Horsepower
36 ounce duck	0.45
32 ounce duck	0.4
30 ounce duck	0.375
28 ounce duck	0.35

If, therefore, you wish to find the amount of power a 12-in., 5-ply belt of 32 ounce duck construction traveling at 2000 ft. per min. with 180 deg. arc of contact will transmit, multiply 0.4 by 12, the result by 5 and the product by 2—the answer is 48 hp., minus 4 per cent, deducted for centrifugal force = 47 hp.

Next you must take into consideration the diameter of the smallest pulley. You must remember that a belt that is made of plies of duck, which plies are held together by "friction" rubber, can not be forced to run over small pulleys at high speed without greatly shortening the life of the belt.

A five-ply belt if made of duck heavier than 30 oz. can in most cases not be run over a pulley smaller than 12 in. in diameter, unless the pulley travels at a speed of less than 1000 ft. per min. Belts constructed of lighter duck, 28-oz. or less, can be successfully run over smaller pulleys provided the "friction" rubber between the plies is of a good grade.

Next consider the fastener and its application. A misapplied fastener often causes all the strain to fall on one half of the belt and when this half has stretched under the excessive load, the strain is transferred to the other half. This finally "shears" the belt in two.

The list of "Dont's" given below is not original with me, but it's another's who evidently knew his subject.

Don't use any certain number of plies as a standard. There is a proper number of plies for every pulley diameter. Choose the belt to handle each particular condition.

Don't cut belts without a steel square. Belts laced out of line will pull out of line; costly shut-downs and torn belts are the result.

Don't use one kind of lace for all kinds of work. There is a correct lace for each drive. No chain is stronger than its weakest link. The lace is the weak link in a belt. Choose the right one for the job.

Don't use belt dressing. Friction surface rubber belts don't require it, and lumps on pulleys and belts are a dead loss in power; if belts slip, find the cause—larger, wider pulleys may be needed.

Don't lace belts too tight. Your belts and bearings both have to stand the strain—the pulling power in a belt is on one side. Loose belts may be made to pull the same loads.

Don't run the seam side of a belt against the pulley. If a belt slips the sealing strip is soon burned out, the belt opens and is soon damaged beyond repair. If idlers are necessary, see that they are free from oil.

Don't let oil and water fall on the belts. Keep them clean and dry—pulleys and belts should be smooth to give good service.

Don't make hasty decisions on belt failures. Increasing the number of plies may result in ply separation if the pulleys are too small. Analyze the failure—then decide on the next belt.

Don't let idle belts hang on moving shafts or against the edge of a pulley. If they are not taken down, suspend them clear of the shaft and pulley.

Don't keep a belt on the pulley with a two-by-four. Re-lace the belt; straighten or line up the pulleys or shaft; eliminate the trouble, and SAVE THE BELT.

Don't run a belt wider than its pulley face. It's power you want to carry—not belt. The only "pull" is obtained over the pulley face; therefore, if more power is needed, widen the pulley face. A wide, thin belt carries more power more economically than a narrow, thick one.

Trouble Hunting---XV

DEVISING TREATMENT FOR ACID WATER. BY JOHN PIERCE

DROPPING BACK to my last article, I will tell the boys the manner in which I ran a half mile of pipe line to the dammed-up spring which I had found. There was no pipe available for the purpose and I was perplexed as to how I could get the water down to the tanks. I found hundreds of 4-in. flues that had been in use years before and when cut out of the boilers were thrown away as useless, though they were still in good condition. It seems as if welding a piece on the end and using them over again had never occurred to the men in charge, and as the company was very rich and was making good money, they simply threw them away and put in new ones. The water, even from the lake when it was in service, would cut the metal very badly once it started to leak, and the flues going to leaking, as flues sometimes do, would soon cut and wear themselves very thin at the ends.

I cut off the ends a foot or two back, and expanded them for 6 or 8 in. on one end of each. On the other end we used the swedge, and, instead of making them larger, we swedged them down until they would fit into the expanded end of the next one. In this way we got around the pipe question. I had the boys heat chapapote till it was boiling, then heating also the expanded end of the flues, painted the inside with chapapote and ran the small end of the next joint into it. This, when cool, made a very good and tight joint.

We then painted the joint heavily on the outside, and using burlap cut into narrow strips, wound it around and around the joints, painting it well with the chapapote as we did so. When it was well bound, we wired it fast with a turn or two of wire and let it cool. We then had a joint that was perfectly water tight. The same thing was done with the other small spring and our two pipe lines were in.

I want to remark once more on the forged crankshaft of which I wrote. This was made from a piece of 4-in. steel and turned down to 2½ in. If any of the fellows think it was a very easy thing to do, I'd "admire," as the Texas man says, to see one of you try it, using the ordinary tools which you can imagine would be found in a blacksmith shop away out in the mountains, using Mexican help, and in Mexico at that. It would surprise most of you to see the things we did in these out of the way places, and with the tools we had to operate with. I imagine most men would simply give up in dis-

couragement and disgust, as I was many times tempted to do so.

There were times when I spent whole days hunting over the junk heaps and old properties to find the proper flanges. These were for 5-in. boiler outlets, and had to have an outside diameter of 13 in. There was no such material at hand with the exception of the saddles that held the mud drums to the boilers at an old abandoned property, and everything was ruined except these saddles. They were of cast iron, both ends cast on a curve, but fortunately for us were very heavy. We took these and turned the flanges off the connecting pipe, then planed them straight, re-turned the outside and tapped for 8-in. pipes, drilling our bolt holes.

We then turned solid plugs to a tight fit, expanded the flanges some, but not enough so that they would break on cooling, painted the threads with a thin coat of "Smooth-on" cement, and screwed in the plugs. These plugs had had two holes one inch in diameter drilled in them, coming within the 5-in. hole in the center that was to be and steel pins driven in the holes. The flange proper was then mounted and secured in the pipe machine by its bolts and the plug started in. As soon as it was so tight that one could not turn it by hand a bar was placed between the pins and resting on the frame. Power was then turned on and the plug screwed home by power. After it was flush with the flange we again placed it in the lathe and turned out the center, tapping it for 5-in. pipe. In making 10 or 12 of these flanges, we spoiled only one; we got one a little too hot, and after screwing in the plug and cooling, the shrinkage was too great and it cracked.

We next decided to rebuild the dam and get the lake ready for the rains that were to come some day, we felt sure; but we say that as yet, after 10 mo. waiting, no rain has fallen. This place is on the top of the continental divide, and when it does rain it rains terribly hard for a few times and then forgets to rain again for many months. We built the dam, however, and not only built it, but we built it 6 ft. higher, intending to back the water up many hundreds of feet further and make sure of plenty of water. In the meantime I was trying to find a way to use the mine water, and had been sending samples all over the country. One could take the water and doctor it anyway he would, and it still would contain acids. We had many men sent us from various companies that manufacture water treating plants. They all made exhaustive studies and tests, and all went away without being able to do a single thing for us.

The best any of them could do was to tell us to use a certain amount of lime, mixed with a per cent of alum and soda ash. In trying this out, however, we found it would throw down a big amount of solids. We were told that when we reached the proper stage with our treatment, the water would not be safe to use at all; that in using our chemicals the water would cease to turn green and would go milky. But after treating it was to be filtered and then the chemicals again used. After this was done, and it turned milky, we would have reached the desired point. If it turned green, we were to let it precipitate, draw off the clear, filter and try again for greenness. The water originally was as clear and sparkling as the best water in the world; the first touch of soda ash, however, would make it a heavy green.

Well, we used chemicals and filtered. With hope going high we added chemicals again to the part drawn off. The part left in the container was a thick, heavy green precipitate that consisted of about 50 per cent of our original water; but when we tried the chemicals a second time, it went green again and our hopes went a glimmering. We let her settle and filtered again. Again we lost 50 per cent of what we started with, and the 50 per cent lost seemed to contain as much solids as had the first. To make a long story short, we kept up the process until we had no more water of the original left, and it seemed as if the last charge was as bad as the first. We then tried heating, first to a certain degree, and then using chemicals and filtering. Then we tried making it hotter and kept on until we had it boiling. Still there was no change at all. We had big open glass containers for our treating and would give each one a fair and impartial trial. In fact, we tried to get the jury to side in and give the chemicals a little the best of it, but nothing doing.

One day, despairing of ever getting results, I got mad and threw a large piece of carbide—just plain, common everyday carbide—into a jar of the water. You should have seen the boiling and bubbling. I thought I'd never seen so much commotion in so small a place. The water turned perfectly black, but as the carbide became more and more dissipated, it cleared a little. Now, after the carbide began working I forgot to be mad, I was so interested. Finally all the commotion ceased and at once the water began to clarify, great clots forming and going rapidly to the bottom. I found, however, that they would leave some little red layers in the water, not alone on the top, but at various points down the jar, that looked like scum. I had a piece of Perolin in my hand at the time, and as there was a beaker on the heater full of hot distilled water, I dropped in the Perolin and let it dissolve, trying, meantime, to figure why the scum did not float so I could scrape it off, or else why it did not go to the bottom and let me have a chance to draw off the good water. Still puzzling over it and slowly stirring the dissolving Perolin, for I had by now picked up and was holding the beaker in my hand, I let a few drops fall into the water, and at once the top layer of red scum began to sink. Seeing this, I emptied the breaker into the jar and down went all the scum to the bottom, where it lay on top of the other precipitate.

Another peculiar thing was that this precipitate seemed much more solid—more like mud—than formerly, and the water above it held nothing in suspension, so that instead of being able to draw off 50 per cent of the water I could draw off about 80 per cent. Drawing it off, I filtered some of it and added my chemicals, my heart in my mouth, from hoping it would be right. Sure enough, the water took on a little white, cloudy appearance which soon disappeared. Then I tried some of it without filtering and got the same result. At this I went to work retreating the containers in order to learn the least possible amount of carbide and Perolin needed to throw it down and leave it clear.

While I was doing this, the boss—or one of them—the one most interested, apparently, in helping me—came in. He did not ask me about the water, but started in on the beaker which I'd treated. Directly he asked me why I had distilled water in that particular glass, as we had been using certain beakers for certain stages

of the water. I then told him it was mine water which had been treated and he could not and did not believe it until I had done it all over for him.

One of the Mexican foremen came in and we told him to look at it, and he volunteered to drink it. Feeling rather squeamish, I told him to do so if he wanted to, and he did; said it tasted a little sour, but was all right otherwise. I never had the nerve to try it myself. We found that while the water was now brought to the point where it could be used, it was going to cost lots of money to use the carbide and Perolin treatment; but in the absence of any rains for the lake, and until the pump could be installed at the lake and pipe lines laid, it would be our only show to go ahead. So I began to prepare for the addition of mine water to our good water.

In the "yards" had been sunk a great tank holding 200,000 gal. of water, and arranged so that it could be filled without more trouble than opening a valve from the air lift discharge. We could fill this tank, but how to clean the precipitate was another thing, for clean it we must, and often. It had a ledge, or step, running along one side at the halfway mark, so at this point I decided to set a pump, and to pump the water, as it was, to tanks above the regular storage tanks, and use them for filtering and treating purposes.

Water Returns to Steam Heating Boilers

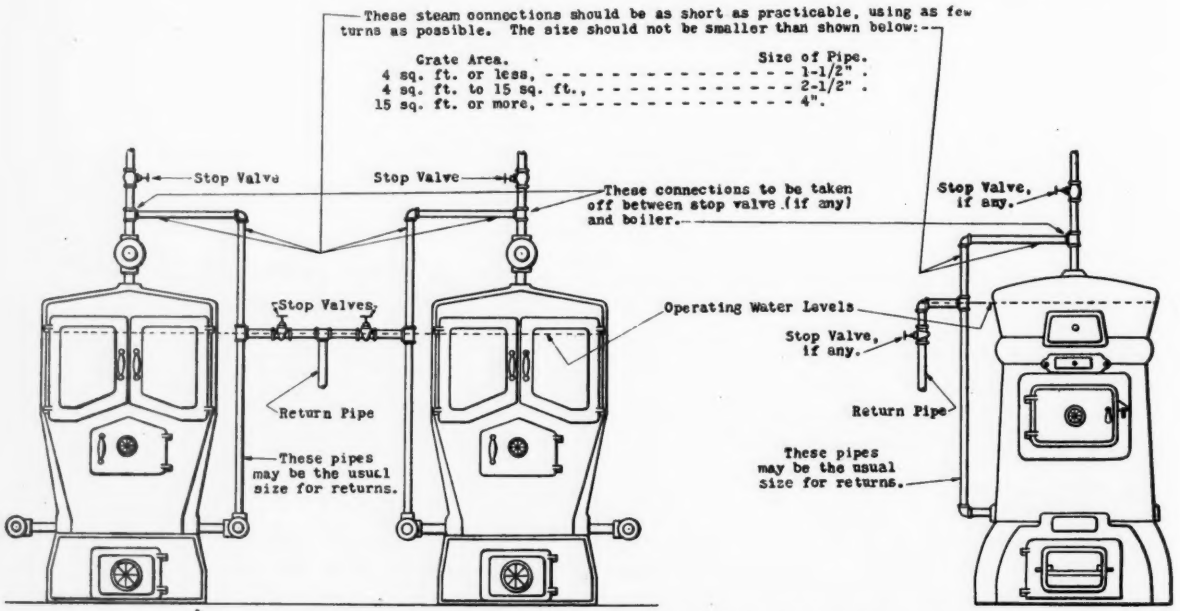
ONE OF the most prolific causes of cracking of the parts of low-pressure, cast-iron, steam-heating boilers is failure to maintain proper water level in the boiler. The principle that a fluid in any interconnected system of pipes or other containers tends to assume a uniform level when the pressure on the surface of the liquid is uniform is the one most to be relied upon to accomplish the desired result. This is because gravity, upon which the principle depends, is infallible.

If this condition of uniform pressure on the surface of the water could be maintained, no difficulty would be experienced in keeping a safe water level in heating boilers using gravity return. Unfortunately, owing to the frictional resistance to the movement of steam or other fluids in pipes, there must be a differance in pressure between two points in order to induce movement of steam, and the difference in pressure required will depend on the volume of steam to be moved. There must be a difference between pressures of the steam at the outlet and return of the boiler to cause the steam to flow into the heating system, and to overcome this difference and cause the return condensation to flow into the boiler, dependence is placed on a head of water in the return pipe. So long as the volume of water required to produce this head may be withdrawn from the boiler without lowering the water level seriously, the system will work satisfactorily.

Use of Check Valves

In some systems the requirements above stated are not met when starting up the system cold, although it will work satisfactorily after being warmed up and brought to working conditions. In such case, the installation of a check valve in the return line near the boiler may make the system workable; but, if more than one boiler is used on the system, complications are introduced. Condensation must be returned to each boiler at approximately the same rate it is evaporating, so as to maintain the water in each boiler at a safe level.

If a check valve is placed in the return to each boiler there is a tendency to disturb the uniformity of water levels as the check valves will not work in unison. If a single check is used in the main return, variation in the rate of evaporation of the boilers will be likely to produce surging of water between the boilers. Also with this arrangement, if the stop valve is closed


These steam connections should be as short as practicable, using as few turns as possible. The size should not be smaller than shown below:-
Crate Area. Size of Pipe.
4 sq. ft. or less, - - - - - - - - - - - - - - - - 1-1/2" .
4 sq. ft. to 15 sq. ft., - - - - - - - - - - - - - 2-1/2" .
15 sq. ft. or more, - - - - - - - - - - - - - - - - 4".
Stop Valve
Stop Valve
These connections to be taken off between stop valve (if any) and boiler.
Stop Valve, if any.
Stop Valves
Operating Water Levels
Stop Valve, if any.
Return Pipe
Return Pipe
These pipes may be the usual size for returns.
These pipes may be the usual size for returns.

CONNECTIONS RECOMMENDED FOR DOUBLE AND FOR SINGLE BOILER INSTALLATIONS

on one boiler before the water return valve, with the boiler still steaming, water would be driven from that boiler to the others, possibly causing overheating and cracking of the sections.

Returns Connected at Water Level

On account of the difficulties pointed out, the National Boiler & Radiator Mfrs. Assn., with the Steam Boiler and Fly Wheel Service Bureau, conducted a series of tests at the works of H. B. Smith & Co., in Westfield, Mass., to determine the practicability of using a suggested water-level connection for the returns.

Evidently with the return connection located at the water level it would be impossible to force water out of the return pipe to a level lower than that at which the connection is made. Therefore, check valves would not be needed on the return pipe to maintain safe water level in the boiler. As sectional boilers are not generally supplied with connections at the water level, and in any case it might not be advisable to deliver the returns at that point, a pipe can be connected from the return opening in the boiler to the outlet pipe as shown in the illustration, and the returns can be connected at a point in this pipe opposite the proper water level.

This arrangement has the added advantage that, if the stop valve on a boiler be closed, there will still be a connection of the boiler to the returns, which will act as a safety outlet, though it should not be depended upon to the extent of doing away with the safety valve. The exact connections shown need not be followed, but the auxiliary pipe should furnish a free connection from the bottom of the boiler to the steam space and to the return pipe, and connection to the steam space of the boiler should always be below the stop valve, if one is used.

It is essential that the upper portion of the equalizing connection be short, direct and of size not less than indicated, so that, if the boiler is steaming heavily when the stop valve is closed, the steam may escape to the return pipe freely, otherwise the water in the boiler may be forced back through the return pipe, thus lowering the water level. With the sizes recommended, this lowering is not likely to be sufficient to cause injury to the boiler.

Many heating contractors have adopted this connection as standard and it is recommended by the National Boiler and Radiator Manufacturers' Association and by the Engineers' Conference of the Steam Boiler and Flywheel Service Bureau, composed of the engineering heads of all the companies doing a boiler insurance business.

Improvements to Oil Tank and Steam Hose Connection

By H. A. Jahnke

THERE ARE many ways for an engineer of a power plant, small or large, to make improvements on some of the apparatus under his charge which may give trouble in some way or another. By making little improvements here and there, we can in many instances make our work much easier. All that we have to do is to give the matter a little thought and not think, as many engineers are in the habit of doing, to leave good enough alone; as long as the wheels turn they are satisfied; this is poor practice, as a man with this idea gets nowhere.

To show how true this is, I relate the following. In a power plant where there is a pressure tank system in use for supplying the cylinder oil to the various steam using apparatus, the tank is arranged and piped up as shown in Fig. 1. The tank is made of 6-in. pipe, capped on both ends and is about 30 in. long.

Much time was wasted whenever it was necessary to refill the tank, as there was no way for the air to escape

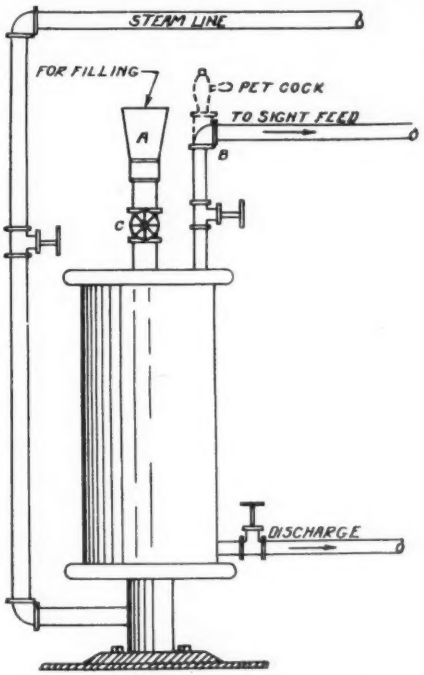


FIG. 1

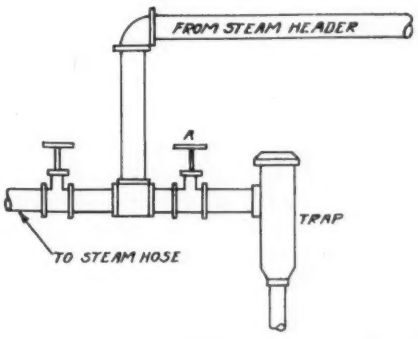


FIG. 2

FIG. 1. CYLINDER OIL FEEDER
FIG. 2. TRAP ON SOOT BLOWER LINE

when pouring oil through A into the tank. To remedy this trouble, I suggested to the engineer to replace the ell B in the line leading to the sight feed with a tee, then placing a pet cock as shown by the dotted lines. By opening this pet cock when filling the tank, this was done in about half the time it took before, as with this arrangement the air could escape through the opening

in the pet cock, hence the tank could be filled so much quicker.

Before this improvement was made, whenever it was necessary to refill the tank when the plant was in operation there was danger of some of the steam using apparatus running dry during this time which no doubt they did at times, hence with this improvement this trouble was eliminated.

Trap on Tube Blowing Steam Pipe

Where steam is used for cleaning boiler tubes, it is advisable to have as dry a steam as is possible for this work, otherwise scale will be formed in the tubes. Frequently we find that when an engineer or fireman is about to blow the soot out of the tubes, the steam hose is connected to the steam pipe and the tube blower placed in the tube and the steam valve opened, when all the condensate that may be in the steam pipe is blown into the tubes. When this condensate comes in contact with the soot, it forms a crust in the tubes, and if a tube scraper is not run through the tubes often, this crust in the tubes will interfere with the heat from the furnace being transferred to the water, which, in other words, is wasting fuel.

A careful engineer or fireman before placing the tube blower in the tubes will first blow all the condensate out of the pipe to which the steam hose is connected.

I have found that it is a good plan to equip the steam pipe that furnishes steam for tube blowing with a small steam trap as illustrated in Fig. 2. Then by opening the valve A shortly before it is time to blow out the tubes, or connecting the steam hose, the steam pipe will be clear of condensate when ready to blow out the soot in the tubes, and by leaving valve A open during the time the tubes are blown, but little condensate will find its way into the tubes.

If the outlet from the trap is connected into an open feed-water heater, etc., this condensate is not wasted. I have mine connected into the receiver of condensate from the heating system and other steam using apparatus and this condensate is returned to the boiler.

Finish for Cold Storage Insulation

Need for Thorough Damp-proofing of Walls, Roofs and Insulating Material. By Junius H. Stone

IN A PAPER presented before the Western Ice Manufacturers' Association, Mr. Wood makes the point that to be durable, insulation must be protected from absorbing dampness which will cause deterioration, by treating not only the insulation but also the walls to which it is attached.

It is reasonably well agreed that both external and internal surfaces of walls should be rendered moisture proof, but frequently care is not taken to see that it is done. The effect of moisture is especially bad in rooms and buildings where the temperature is held around freezing, such as for storage of eggs and ice. Warming of the room walls by the sun during the day and cooling at night will result in the gathering of moisture on the walls which will penetrate the insulation, alternately freeze and thaw, and thus destroy the material as well as its insulating value.

This is the process by which granite cliffs are destroyed, hence it is evident that insulation on walls and roofs cannot withstand such action. The effect is not so serious in rooms where the temperature is at all times below freezing, as the moisture never has a chance to melt and penetrate to the interior of the material.

Damp-Proofing Walls

Smearing a wall with a coat of melted asphalt to which the insulating material is stuck is not effective. Walls are apt to be damp and cold so that the asphalt chills before it has time to penetrate the crevices and obtain a grip, and not only is it a failure as protection against moisture, but it does not hold the insulation to the wall. A coat of liquid asphalt should be first applied, after making the wall reasonably dry. This may be done with a hand brush, but better with an air brush, as this will drive it into the crevices and insure that the entire surface is coated. When this first coat has become practically dry, the insulation can be set on it in hot asphalt with the certainty that, if the job is carefully done, the insulation will stay put. The insulation may be put on over the first coat with portland cement, but the hot asphalt will make a better bond.

Roofs

In all cases insulation should be designed to be applied on the top of the roof slab, as it is cheaper in first cost and permits of easy protection. Sheets are laid in hot asphalt, all the surfaces mopped with the same material, and the built-up roofing applied in hot asphalt over the insulation proper. A white top roof is of assistance to the insulation in throwing off heat, experiments showing that there is a difference of 15 deg. at the insulating surface as between white and black top roofs.

Inside Finish of Insulation

Portland cement has been used, applied in two coats, each ½ in. thick, or asphalt finish, sometimes put on at the factory, sometimes mopped on after erection. Cement, if scored into 3 or 4-ft. squares, has given satisfaction in most cases as cracking is thus localized and, with the walls painted small cracks can be sealed. If unpainted, the cracks permit moisture to enter the insulation proper, damaging the insulation and tending to crack off the cement from the wall. It is better to leave the cement surface a rough float finish, as the paint will get a better grip on such a surface than if it is troweled smooth. Unpainted cement will absorb moisture which, on freezing, will disintegrate the cement and the insulation behind it.

Mopping on asphaltic or mastic finish has the disadvantage that small openings may be left in the coating through which moisture can get to the interior. Such a coating has no value as a physical protection and is suitable only when the stored goods are to be moved infrequently. A first coat of cold liquid asphalt followed, while the coat is tacky, by a paste troweled on gives better results; but care must be taken against fire while the first coat is drying out, as the solvent in many cases gives off inflammable fumes and a match or lighted cigaret may cause an explosion. Even if not explosive the fumes are unpleasant and it is advisable for the workmen to wear gas masks to avoid being overcome by these fumes.

The best solution of the problem seems to be applying the asphalt coating at the factory under pressure

so that after the sheets are put in place only narrow seams are left to be closed with the plastic material. Care should be taken that the asphalt mixtures are of such nature that they will not contract and crack at low temperatures.

Finally, the insulating material should be as close grained and dense in structure as is consistent with its acting as an insulator, in order to resist the entrance of moisture. Reduction of the amount of material in the sheet to get greater porosity does increase insulating value, but only to a small per cent; and this results in a weaker sheet which is often broken or cracked with the net result that the insulating value is less than for a wall covered with whole sheets of the denser material. If the rear of the insulation is not well protected against moisture, the appearance of the inside is of little consequence so far as effective protection against heat leakage is concerned.

Coal in Storage Today

AN ANALYSIS of the coal situation, the purpose of which is to give business men information regarding possible fuel supplies in the event of a strike of miners on April 1, has been issued by the Coal Bureau of the Natural Resources Department of the Chamber of Commerce of the United States. The bulletin carries charts covering conditions in particular localities throughout the United States.

A general summary covering the situations with which the booklet is concluded, says:

"Factors which will control supplies in case of a strike that closes the mines in union fields will be stocks on hand and output of non-union fields.

"As the anthracite field is 100 per cent unionized, all supplies in the event of a complete closing of the mines will have to be drawn from stocks on hand. Anthracite, unlike bituminous, can be safely stored for long periods. This has made possible a system of distribution comparatively uniform through the year. It is reflected in the fact that anthracite mines run more regularly than bituminous, and shipments from mines show comparatively small variation between winter and summer months. Actual consumption, however, is several times greater in winter than in summer. Reliable figures on which to base an estimate covering possible anthracite supplies in the event of a strike completely closing the mines are not available. There are no figures available showing stocks in the cellars of consumers, nor in the hands of dealers; nor figures showing the relative rates of consumption between summer and winter months. The United States Geological Survey has published figures based on statements from 648 typical retail dealers, showing the day's supply of anthracite usually carried by them on April 1, as follows:

April 1, 1919	31 days
March 1, 1920	21 days
April 1, 1921	36 days

"If these figures should hold good for all dealers, there would be in dealers' hands, normally, on April 1, about a month's supply. The Geological Survey also gives the following figures covering approximate stocks of anthracite, domestic sizes, in hands of producers January 1, 1922:

	Tons
At Eastern points	2,000,000
Storage at Great Lakes ports	1,000,000
By-product coke for domestic use	1,000,000
Total	4,000,000

"Assuming an equal supply on hand April 1, and assuming further, that this supply could be evenly distributed among all consumers, it would last several months, as it would be available at the beginning of the warm summer months when consumption is lightest. As noted above, however, distribution and consumption do not run parallel. Moreover, each locality has its own peculiar conditions making it different from the others. Storage capacity and supplies actually carried vary in the different localities, and there is also considerable variation in climatic conditions. A late spring with cold April and May would increase consumption several times over normal. In other words, the probable disarrangement of the usual system of distribution which would result from a strike, the variation in storage capacities and stocks in storage, with the uncertainties of weather conditions make it impracticable to estimate the length of time the supplies of anthracite on hand would last.

"The following statement of the U. S. Geological Survey will be of interest as indicating the days' supplies of bituminous coal in the hands of various classes of consumers in the United States on Jan. 1, 1922:

	Days
By-product coke plants	42
Steel plants	48
Other industrials	51
Artificial gas plants	89
Electric utilities	51
Coal dealers—bituminous	33
Railroads (estimated from incomplete data)	35

"Subsequent statements are that supplies have increased to some extent up to Feb. 11.

"The consumption of bituminous coal in 1921 averaged 32,000,000 T. per month, or about 7,600,000 T. per week. Bituminous consumption is not subject to the extreme seasonal weather fluctuations affecting anthracite. Bituminous, however, is directly affected by industrial conditions, reflecting immediately a revival or depression. This variation is shown by a comparison of the active year of 1920, when the total production was 556,516,000 T., with the depressed year of 1921, when production totaled 407,048,000 T.

"The Geological Survey reports that stored bituminous coal on Jan. 1, 1922, totaled 47,000,000 T. The Geological Survey further notes that stocks cannot fall much below 20,000,000 T. (as in 1920) without danger of a "coal panic." The quantity of coal, therefore, which can be drawn from stocks on hand before a serious situation develops is about 27,000,000 T. To this supply there will be continually added the output of non-union fields. The strike of 1919 furnishes some precedent as to what can be expected. At that time non-union districts furnished approximately 4,000,000 T. per week. Assuming this year's consumption to be comparable to that of 1921, 7,600,000 T. per week, the supply from non-union fields would fall short 3,600,000 T. per week of meeting the demand. To cover this deficit, we might have the 27,000,000 T. of stored coal, which would last

approximately eight weeks. This period might be lengthened by increased production from the non-union fields and there are reasons to believe this production will increase, but how rapidly and to what extent can only be conjectured.

"The above are average figures covering the entire producing and consuming areas, and rest on a theory of even division of product and uniform storage capacity and uniform stocks on hand throughout the country. In reality, however, such uniform conditions do not exist in the different communities. Moreover, in case of strike the ordinary lines of distribution are so disarranged that there results great variation in the ability of different communities to secure needed supplies."

Spineless Cactus

By H. A. Cranford

I HAVE never seen what the botanists call a spineless cactus, but I meet engineers sometimes that somehow make me think they are something like this piece of nature's work.

A short time since, one of the large plant owners of this city called me and asked me to call on him at his office. When I called on him he told me that he was contemplating making some changes in his power plant and wanted my opinion on the matter. We went into the details of the proposed changes and I gave him the best advice I could.

After we had finished I asked him why he had not called in his engineer and consulted with him. I had found out in the course of our conversation that he had not talked the matter over with his engineer. He replied that while the engineer he had was one of the best operating men and mechanics that he had ever had in his plant, he was worth nothing to him in an advisory capacity because everything he said to him he would answer "Yes." He said that it mattered not what he discussed with him he invariably agreed with him on everything.

Now I have met a lot of these "Yes" fellows in my time. And if there is anything in the world that is absolutely disgusting to me it is the fellow that always agrees with me on everything and never expresses an opinion of his own. He always agrees with his superior no matter what the subject is and thinks he is putting himself right with the boss. He goes on and on for years, always agreeing, with never an opinion of his own and then when the big questions come up, his big chance, he is ignored because they know what his answer will be without sending for him.

This "Yes" fellow in the engine room is nothing more than a vine that clings to anything that is offered. There isn't an ounce of hard wood in its makeup. I had rather be dead wrong about a matter, believing that I was right, than to agree with the other fellow all the time. I know that I would have the respect of my fellow man to say the least of it. And the man who always agrees, and never disagrees, is generally questioned as to his truthfulness, because it is a known fact that exactly as there are no two people alike physically, neither are there two people exactly alike mentally. I wouldn't give the snap of my finger for the man who always agrees with me for I couldn't depend upon his opinion.

I worked for the manager of a building who invariably disagreed with me at first on every subject concerning the engine room that I brought up. It would get my goat at first, when I knew what I was talking about and knew that I was right. But I found out afterwards that he would argue with me in order to bring out what I knew about the matter under discussion, and thereby gain knowledge himself. And after these long disagreements over different engineering problems, I nearly always got what I wanted.

When big changes come up the boss wants some one that he can depend on to disagree with him if he thinks that the boss is making a mistake. He wants a man that has the backbone to express his opinion against the thing in hand. And when two people disagree on a thing they generally argue the pros and cons of it and each one will come out better posted on the subject under discussion.

After I had finished discussing the matters with the employer I visited in the engine room and talked with his engineer. I brought up several subjects connected with engineering and he agreed with me on everything. And on some of the subjects I made statements that were actually contrary to what was considered good practice, things, in fact, that the evidence of my own eyes showed me were contrary to the way he was running things himself, yet he agreed with my statements in a very pleasant way. Anyone with an ounce of brains knows that that kind of an engineer will never get anywhere.

As engineers, let's first find a basis for our opinions. Then when once formed stick to them until we are convinced fairly that we are wrong, and not be known as simple "Yes" men (spineless cactus) and when the boss wants to discuss changes in our engine rooms, be ready to discuss things in an intelligent way, and disagree with him when you see him heading in the wrong direction.

Preliminary figures showing the percentage which the amount paid to each labor group bears to the total labor cost of a six-room house, are given by the Department of Commerce, as follows:

Total Labor Cost 100 Per Cent

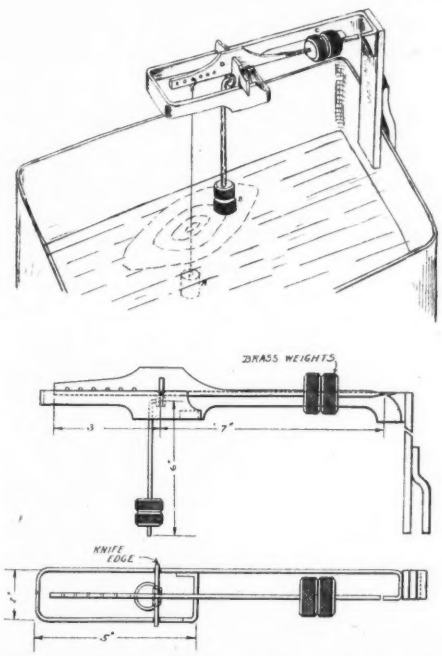
Trade	Frame house	Brick house
Carpenters	49.6	32.2
Bricklayers	6.2	21.5
Hod carriers	2.2	6.7
Plasterers	7.9	8.8
Plumbers	8.7	7.6
Electricians	2.6	2.5
Painters	10.0	6.3
Common laborers	6.3	9.9
All others	6.5	4.5
Total	100.0	100.0

These averages were constructed from reports covering a large number of six-room brick and frame houses throughout the country.

The relation of the amount paid to the various groups to the total labor cost varies according to the types of construction prevailing in the various localities; however, these averages give a fair view of the general distribution of labor costs.

Gravity Indicator for Water Treating Plants

As a result of the annoyance caused by the breaking of hydrometers, this simple gravity indicator was designed. It was also found in connection with hydrometers that if they were placed in hot liquids the paper scale would twist and throw the hydrometer out of calibration rendering it useless. In the water-treating plant caustic soda is one of the chemicals used in liquid form at a gravity of 34 deg. Baumé. The indicator is made



GRAVITY INDICATOR WITH ELEVATION AND PLAN OF BALANCING ARM

of strap iron 1/8 in. thick and is fastened to the caustic soda tank as shown in the sketch.

The principle involved is that of Archimedes, that is, if a solid body is immersed in a liquid it will be buoyed up or lose weight to the extent of the weight of the liquid displaced. Thus a body will weigh less in a dense liquid than in a lighter one. The indicator is in effect merely a balance, the difference in the weight of A and the volume of the liquid displaced being balanced by the weight C. At such a balance the liquid is exactly 34 deg. Be'.

Probably the most important part of the balance is the pendulum weight B. It will be noticed that when the indicator is in the balanced position as shown the moment about the knife edge due to B is practically zero. Now if the liquid should happen to be lighter than 34 deg. Be', the tendency is for the body A to sink and it does so until the moment created by the moving of B outward is sufficient to balance the difference in weight due to the lighter solution. In such a case the beam would move above the pointer and indicate a light solution. If on the other hand the liquid happened to be heavier than 34 deg. Be' the body A would be buoyed up to a greater extent and the beam would move below the pointer until the pendulum weight B produced a moment about the knife edge sufficient to restore a balance. Thus it is seen that the sensitiveness of the balance is regulated by the weight B and its distance from the knife edge.

The wire from which A is suspended is very fine in order to avoid errors due to the different buoyant effects with different depths of immersion. It is best to design the weight A just a trifle heavier than the weight of the displaced solution at the desired gravity so that the weights C are small. By drilling a number of holes along the arm D, the indicator can be used for a variety of densities.

From a practical standpoint, these indicators are accurate and remain in calibration a long time and the operators find them more convenient than a hydrometer, especially when valves are to be operated to get the proper density. C. W. Jackson and C. E. Joos.

Condenser Tube Corrosion

In a booklet which recently came to my attention I find the theory advanced that corrosion of condenser tubes is largely due to electrolysis. This, of course, is not the first time that such a theory has been brought up. Many times before now it has been discussed and laid on the shelf, signifying one thing: knowledge of the cause of an evil amounts to nothing unless it serves to point the way to a remedy.

This is one of the reasons for which the booklet is notable: it presents a possible means for preventing this corrosion, in the use of metallic packing at both ends of the condenser tubes. By this method a short-circuit is made, and electrolysis ceases. Experiments prove that with strips of brass and iron immersed in salt water, when no connection is made between them, electrolysis occurs. When the strips are connected at one end electrolysis is increased, but when connection is made at both ends it ceases immediately.

While this, without doubt, is very true, I have never had the opportunity of examining a condenser so packed, and cannot say positively whether it would stop corrosion entirely. Even if it does prevent electrolysis, there is a chance that corrosion would still be present, due to possible liberation of hydrogen or other chemicals from

the solution; for the plan suggested does not stop the generation of electricity, it merely provides a short-circuit, preventing a flow of the electric current through the solution.

Now the direct result of electrolysis is that brass from the tubes is carried away to the shell, which eventually becomes brass-plated. By this means the brass plating should, in the end, become thick enough to prevent further electrolysis.

But electrolysis is, to my mind, not so much the means as the original cause, or beginning, of corrosion. The microscope shows quite a difference between the surface and the metal directly beneath it in a condenser tube. When electrolysis has eaten away a certain portion of the brass of the tubes, electrolysis ends, as suggested above. By this time, however, the surface of the brass has been removed, exposing the softer inner metal, which the chemicals in the water are free to attack. Corrosion proceeds and the final result is that new tubes are necessary.

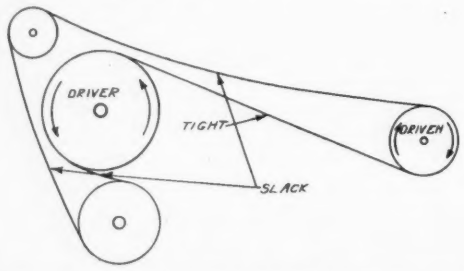
So, therefore, two things become evident: First, that the effect desired is to minimize all chemical action; second, that with tubes and shells of the same material, chemical action is reduced to a minimum (unless there is some other metal available which is less subject to such action).

Brass is better for condenser tubes than is iron or steel, but brass is too costly for shells, also it is rather likely to corrode. On the other hand, steel tubes would seriously impair the usefulness of the condenser, as they do not radiate heat nearly so fast as brass tubes. Nevertheless, if the tubes were given a thin plating of iron or steel, they would give off heat almost as readily as before, while they would be less liable to corrosion and would prevent electrolysis. Here, I am sure, lies the solution to the problem, and I am assured that this plan will eventually be adopted. ACKER PETIT.

Improvement in Idler Arrangement

IN THE March 1 number of Power Plant Engineering Leon L. Pollard shows how he arranged a belt drive so that the driven pulley would run in the opposite direction than would be the case with an ordinary open drive.

The writer objects to this form of drive because of the fact that the idler which is marked B is subjected



USE OF IDLERS ON SLACK SIDE OF BELT DOES AWAY WITH CROSSED BELT

to an enormous pull by the belt from the driver pulley and from the driven pulley. In other words, the belt leaving idler B is tight and so is the belt approaching it; consequently the power loss is very great unless ball-bearings are used or unless care is exercised in setting up the idler B and liberal lubrication is provided. It is always poor design to place an idler on the right side of any belt. Idlers should be placed on the slack side only.

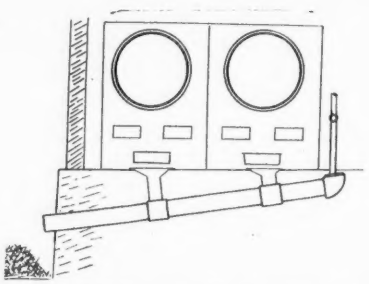
Herewith is a sketch showing how the same result could have been obtained with the use of two idler pulleys placed in a slightly different way. These idlers are larger than those shown by Mr. Pollard but if they are too large—so large that the design would have been impossible on account of space conditions—three idlers could be used so as to keep the belt close to the driver pulley while wrapping the belt around it in order to create a sufficient arc of contact so that the belt will pull without slipping.

In arranging drives of this kind it is bettter to place the idlers around the large pulley rather than the smaller one because of the fact that a large pulley can get along with less arc of contact without slipping than can a smaller pulley.

As will be observed, with this arrangement the belt is slack at all points between idlers and main pulleys and is tight only between the driver and driven pulleys, just as it should be. N. G. NEAR.

Simple System of Handling Ashes

ONE OF the most disagreeable things which the average engineer has to contend with is the handling of the ashes, and in many plants funds are not available for installing automatic equipment, and in many cases the



ASHES DISCHARGED FROM PLANT BY STREAM OF WATER

plant is too small to warrant the expense or to show much of a saving. It is frequently possible, however, to simplify this problem by making a study of the conditions. For instance, the writer visited a plant where he saw a simple, though practical scheme for handling the ashes which worked out satisfactorily. The general scheme is shown on the sketch, from which it will be noted that the boiler room floor was about 10 ft. higher than a vacant lot in the back of the plant. A length of 12-in. terra cotta pipe was laid on a good angle, as shown, with two tees located so as to receive the ashes from each boiler, the top of each riser being fitted with grate bars making it necessary to reduce the ash to at least 5-in. size before it could pass into the pipe.

When the fires were being cleaned and the ash was being discharged, a 2-in. water line connecting into the upper end of the duct was opened which served to flush the ashes out to the pile outside. This whole affair did not represent much of an outlay, but at the same time did the work effectively. It is not always possible to

have conditions such as this where the boiler room floor is higher than the point of discharge, and where the space is available to allow the ashes to be discharged and drain off, but it does illustrate the possibility for saving the engineer from this disagreeable task if a proper study and a real attempt to improve conditions is made. M. A. SALLER.

Safety Valves in Ammonia Systems

THE TIME of the season is at hand that all refrigerating plants should be looked over and any overhauling or repairs done before the busy season approaches. There has been a lot said about overhauling and operating, but the safety part has been somewhat slighted or overlooked. Every now and then we hear of an ammonia explosion; some are disastrous and some minor where the majority of cases could have been avoided if proper precaution had been taken. Practically all compressors have safety valves on them, usually set at 300 lb. gage and let it go at that and consider that condenser pressure never goes that high and if it does, the safety valve will take care of it.

It's not the compressor alone that has to be contended with. How many plants have safety valves on their ammonia receivers? Is the receiver capable of carrying 300 lb. pressure? It probably was when installed; but after some years of service it may not be, due to strains and deterioration; furthermore, you cannot look through a welded seam on any tank, so why not have a safety valve on receiver set at about 260 lb. gage which would be a safe margin on operation? Even if pressure should exceed 260 lb. and blow to relieve itself in extreme times, it would be far better to lose only a small part of the ammonia than to have an eruption and lose all with the consequence of a shut-down, which all try to avert. It also would be a good precaution in case of fire, no matter where the receiver is located, for pressure would build up and burst, as it could not return through the compressor when the discharge valve is closed. With a safety valve on the receiver, no bad effects would be experienced. E. G. M.

Steam Cylinder Lubrication

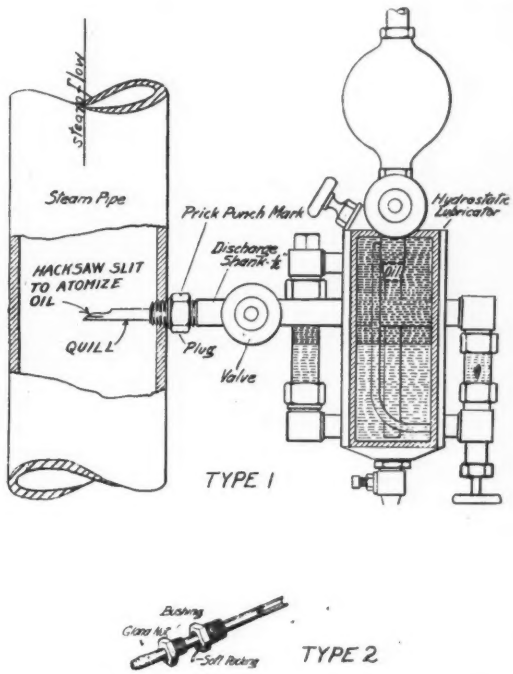
J. E. STEELE'S communication, page 288, March 1 issue of Power Plant Engineering, is interesting. His letter relates to a previous article (Jan. 15 issue, page 140) concerning the internal lubrication of a steam-driven pump. Mr. Steele has the right idea concerning the difference in results between feeding large drops of oil and small drops. Also, his suggestion of putting a nipple in the steam line to the pump in order to conduct the oil to the center of the pipe and thus cause a better mixing of oil with the steam is good. He might, however, have gone a little farther with his analysis.

The purpose of internal lubrication is twofold: (1) To lubricate the moving parts by interposing a fluid film and so prevent metallic contact, and thus substitute fluid friction for mechanical friction; fluid friction is much less. (2) To form a piston seal in order to prevent the blow-by of steam from one side of the piston to the other.

In order to accomplish the foregoing a suitable oil must be selected to suit the actual operating conditions, such as pressure, quality of steam (wet or dry) speed, and the method of application.

If the correct oil is selected and applied in the most approved way, then a very small quantity only will give satisfactory results, as proved by many actual tests. Aside from the needless waste of oil, as usually obtains in many plants in cylinder lubrication of various steam units, oil-laden steam is objectionable in heating systems, feed water heaters, or return condensate to the boilers.

In line with the suggestions made by J. E. Steele, I am sending herewith a sketch of a device known as an oil atomizer that may easily be applied to almost any piece of apparatus of any consequence in a steam plant.



ATOMIZER FOR STEAM CYLINDER OILS

The velocity of the steam flowing in the pipe crushes and atomizes the drop of oil fed to the end of the "quill," thus enabling the steam to carry it to all the internal parts requiring lubrication. CHARLES J. MASON.

Anti-Rust Lubricant

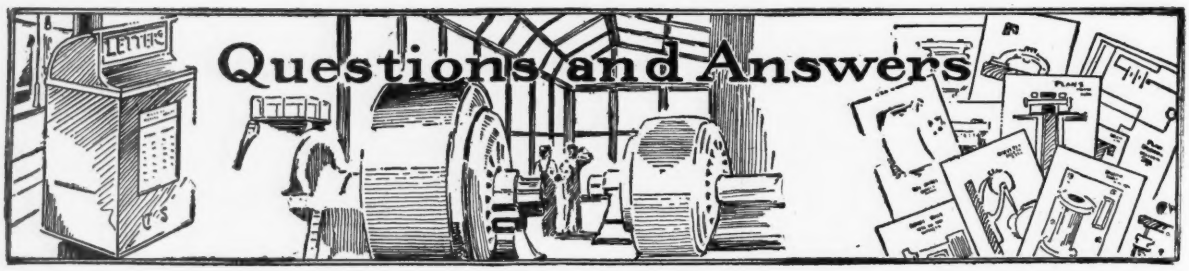
IT LOOKED like a dark axle grease. The old engineer was applying it on the springs of an auto-truck.

"Helo, Dan, what's the big idea—axle grease on spring leaves?"

"Hello, boy. It is and it ain't axle grease. You understand spring leaves will rust and then snap off if not taken care of. What I have here is one pound of melted India rubber scrap, one-half pound of grease and one-half pound of graphite. This mixture will give life and buoyancy to the spring."

It sounds reasonable to me, so here it is for you.

J. B. DILLON.



What Is the Remedy for the Burning of Soot in Stacks?

WE HAVE at our plant two 175-hp. return tubular boilers each having a separate stack 100 ft. high and 36 in. in diameter. A little over a year ago we installed a system of soot blowers which have proved unsatisfactory in removing soot and ash from the tubes.

About three or four months ago, however, after No. 2 boiler had been off for cleaning and put back on the line, the soot in the stack caught fire and came out in sheets of flame that fell over onto dwellings in the vicinity of the plant, setting one or two of them on fire. Last week this same thing occurred on No. 1 boiler.

This burning out of the stacks constitutes a fire hazard, and it must be stopped even if we have to shut down the plant. What is the cause of this occurrence and how may it be remedied? Any suggestions from readers of Power Plant Engineering will be welcomed.

W. F. C.

Oil Deposits on Boiler Tubes

WE HAVE been having trouble with our oil-fired boilers on account of unconsumed oil being deposited on the tubes. If left for any length of time, this oil becomes hard and is difficult to remove.

I would like to hear from Power Plant Engineering readers as to what I can do to prevent this formation. When I take a boiler off the line, I cut down on the fires gradually, taking at least half an hour to perform the operation, principally for the purpose of preventing the brick work from contracting too quickly. At first I thought that this may have been the reason for the oil on the tubes, but I have tried shutting off the burners instantly, with the same results. What else could have a bearing on the situation? F. J. I.

Heat Loss in Flue Gases

IN THE Feb. 15 issue of Power Plant Engineering there appeared an answer to a question under the above caption in which there is an error in the construction of the expression for the heat loss. The answer or explanation given as to how constant 58.46 is derived seems the only one that could be offered and yet, in fairness, the commentator should have pointed out the error in the expression.

Most of the formulas used in this line are subject to so many "ifs," that they are too dangerous to be used except by an experienced person who can make proper allowances for the shortcoming of the formula, and this one is no exception.

As pointed out in the answer, the stack or flue gas loss is directly proportional to the weight of the dry gas or product of combustion per pound of fuel, and the product of combustion under the assumed conditions will consist only of N_2 and CO_2 in the same proportion, volumetrically as N_2 and O_2 in the air used for combustion. Air consists of N_2 and O_2, and after combustion under the assumed conditions takes place, all of the O_2 is converted into CO_2 and N_2 remains unaffected by combustion, so dry gases will be composed of N_2 and CO_2 only.

The weight of gases is proportional to their atomic weight, and therefore, the weight of O_2 and CO_2 will have the same ratio as their atomic weights, that is the weight of oxygen to the weight of CO_2 formed from it will be 32:44, or as their respective atomic weights, and from this it is self-evident that the weight of O_2 used for combustion is less than the weight of the resulting gases from combustion.

The weight of oxygen which entered into the combination with a pound of carbon was 2.666 lb., then the weight of CO_2 resulting from the combination will be

$$W \div 2.666 = 44 \div 32 \text{ or}$$

$$W = 2.666 \times 44 \div 32 = 3.666 \text{ lb.}$$

instead of 2.666, and the product of combustion under the assumed condition will weigh not 11.6 lb. as taken in the expression, but 12.6 lb. The expression takes no account of 1 lb. of carbon which entered into the combination to form CO_2 and this makes an error of over 8 per cent to start with, and even if all the other ideal conditions could be approached in practice, which is hardly probable, the expression would be useless unless corrected.

H. MISOSTOW.

What Causes Leaky Tubes?

ON PAGE 241, Feb. 15 issue, H. L. W. does not agree with C. G. Harden on the subject of "What Causes Leaky Tubes," as expressed by the latter in his article in the Jan. 15 number, and states that he would like the subject discussed more at length.

In reading the reasons given by Mr. Harden for the tubes leaking, it will be noted that the change in setting is given as the principal cause for less tube trouble than was previously experienced and also for the increased fuel economy.

"After the flues were rolled, no further trouble was experienced in over a year."

Probably had the tubes been rolled properly they would have remained tight for the same length of time without the change in setting.

Tubes properly installed, rolled and beaded should remain tight much longer than one year, even with the first type of setting illustrated by Mr. Harden, unless some bad practice in operation of the boilers is used or the feed water is highly corrosive.

He does not tell us how much coal was saved, but I would hazard a guess that the B.t.u. lost in the water

which leaked from the tube ends, together with the reduction in efficiency of the boiler due to the tubes which leaked being wholly or partially plugged by soot and scale was more responsible for the saving in coal than the change of setting.

I have operated and repaired a large number of horizontal tubular boilers during the past 25 yr. and my present plant of four 72-in. by 20-ft. horizontal tubular boilers are the first to give trouble with leaky tubes either front or rear and I am thoroughly convinced of the cause.

Until the past 4 or 5 yr. it was customary in our state for boilermakers to roll the tubes and flare them to an angle of about 30 deg. This practice is now prohibited by the State Boiler Code.

The ends of the tubes not being beaded project beyond the head and the intense heat burns the metal, which will, sooner or later, crystallize and break off. Then too, soot collects on the top and side portion of the projection and when the boiler is laid up for any length of time, unless the back head and tubes are thoroughly swept, to remove all soot, will soon collect moisture; sulphuric acid is formed, rapid corrosion sets in, and soon the tube ends are leaking. Rolling may be resorted to, but it is only a question of time, and not long at that, when new tubes will be the only remedy. When they are installed, rolled and beaded thoroughly, and proper care taken of the tubes and boiler, they will remain tight during the life of the boiler unless the water is bad, in which case frequent renewals may be necessary.

It was the custom before the writer took charge to clean the combustion chambers while the boilers were in full operation, necessitating having two back connection doors open for 2 or 3 hr. at a time while the soot was pulled out with a hoe. While this was being done, cold air was rushing in against the back head and tube ends, causing abnormal contraction and a heavy strain on the rear end of the boilers, which, no doubt, caused the tubes to leak sooner than they would have done had this method of cleaning not been used.

Our boilers are being retubed and when completed I do not anticipate any trouble from leaky tubes for a long time.

A. K. VRADENBURGH.

DOUBTLESS THE change made by C. G. Harden was accomplished without considering the effect it would have on fuel economy or boiler efficiency.

An old-style boiler setting is shown in Fig. 1, in which the combustion chamber is filled in on a level with the grates. It was thought in those days that the best results were obtained by holding the flame as close to the boiler as possible.

A later style of setting is shown in Fig. 2, which is an improvement over the style shown in Fig. 1.

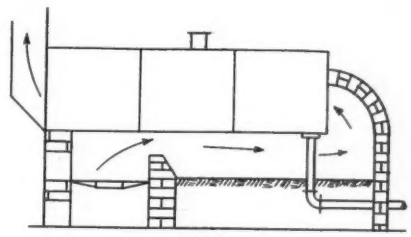
In this style of setting the grates are about 28 in. from the boiler shell and the combustion chamber is partly filled in and bricked with a sloping floor from near the top of the bridge wall to a point near the blow-off pipe. While this style of setting may be all right for anthracite coals, it is a most unsatisfactory setting for bituminous coal or any fuel that produces a long flame.

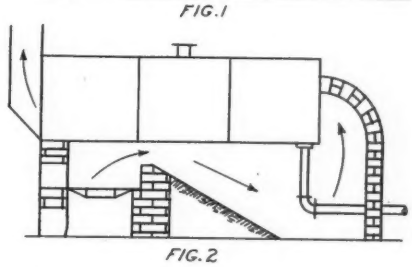
It has been shown from experiments that for fuels of this class the grates should be at least 48 in. from the boiler shell, and the floor of the combustion chamber may be on a level with the floor of the ash pit, as in Fig. 3.

Room is required for the complete combustion of any bituminous fuel, as the chilling of the flame as it comes in contact with the relatively cold surface of the boiler, checks combustion and carbon is precipitated, forming smoke; this is accompanied by a lowering of temperature and the deposit of soot upon the heating surfaces results.

It is a well known fact that smoke shows incomplete combustion, which means inefficiency, and if smokeless combustion is to be realized the flame must be kept from contact with the boiler heating surfaces.

The combustion chamber of a return tubular boiler serves three purposes: It acts as an expansion chamber and delays the passage of the gases, thereby insuring the absorption of more heat through the shell of the boiler,





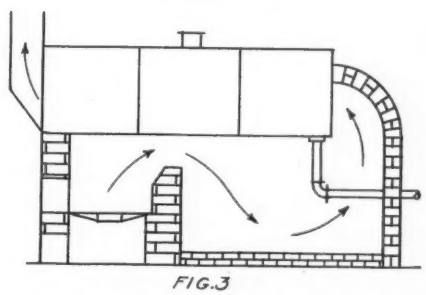


FIG. 1. OLD STYLE BOILER SETTING WITH SMALL COMBUSTION CHAMBER

FIG. 2. LATER STYLE OF BOILER SETTING WITH INCREASED COMBUSTION CHAMBER VOLUME

FIG. 3. MAXIMUM VOLUME COMBUSTION CHAMBER AND LOWER GRATE

which means lower temperatures in the uptake and the waste of heat to the chimney will be less. It acts as a trap in which fine ash carried over from the furnace by the gases of combustion is collected, thereby preventing in a large measure the deposit of such ash in the boiler flue.

It also acts as a combustion chamber in which the process of combustion, if unfinished in the furnace proper, may be completed. E. C. WELLS.

I TAKE issue with the statement of C. G. Harden published in the issue of Jan. 15. I do not agree that by raising the combustion chamber he eliminated the flue trouble.

Raising the combustion chamber or bridgewall necessarily caused a greater draft, as the gases of combustion had less space through which to pass and therefore caused the gases to have a higher temperature upon reaching the tube sheet. Unequal expansion and contraction in the setting shown in Fig. 1 of Mr. Harden's article would cause the flues to leak more readily.

Perhaps the rolling of the flues had something to do with eliminating the trouble and not the raising of the combustion chamber. As these boilers had been operated only about 6 mo., one could hardly blame scale for the leaky tubes, but scale is also a detrimental factor in causing flues to leak, as it keeps the water from the surface of the flues and causes them to overheat. Consider a water tube boiler, for instance. The fire is directly under the tubes, yet they do not give trouble or leak at the headers unless there is a heavy scale formation. CHARLES W. CARTER, JR.

Chattering Nonreturn Valves

IN THE March 1 issue, on page 287, R. K. asks about the chatter of nonreturn valves.

I have had a similar experience with non-return valves used with reciprocating engine.

The trouble with these valves apparently came from the fact that the makers were not informed of the service to be given by the valves and therefore furnished valves which were designed for use on turbine service, or where the service was continuous and not intermittent.

The chatter was entirely eliminated by making the dashpot of these valves a closer fit, and I believe that if these valves are of a character having a dashpot or something of that nature, the same results can be obtained by making this dashpot fit close enough to prevent the valves from closing between the strokes of the engine.

My suggestion would be to put the situation directly up to the maker of the valves and demand that they make good; that is, that they furnish you with valves that do not chatter, but the makers must be given all the data covering the installation and work required of the valves. HENRY D. JACKSON.

I CAN well understand the uncomfortable feelings of L. K. when he goes into the boiler room and hears the "clapper" of his nonreturn valve pound the seat ring as explained in the March 1 issue.

I had just such an experience as L. K. In the plant where I am employed we have three 500-hp. water-tube boilers, each one fitted with a 10-in. gate and 10-in. automatic nonreturn valve of a standard make. We had quite a little trouble with No. 1 boiler which happened to be nearest the engines, of the Corliss valve type; every time the valve opened to admit steam the clapper would hit the seat ring in No. 1 boiler. I was well aware of the fact that this condition could go on only so long; in other words until the clapper would turn out the ring. This happened sooner than expected, with the result that I was forced to take the valve down and remove the interior. Then I had a neat-fitting ring made for the piston of the nonreturn valve, put the seat ring back with new retaining screws and since doing this I have had no trouble and have eliminated all disagreeable noise and the automatic feature still remains the same as applied to the valve.

Now, I will venture to say that the boilers of L. K.'s Nos. 3 and 4 are the ones nearest the engine taking steam; in other words, they have a short steam line, while Nos. 1 and 3 have a longer line and, therefore, act as a receiver for the steam; thus the pressure does not get a chance to fluctuate as in the case of Nos. 2 and 4.

So my suggestion to L. K. is, as soon as possible, to have the valve removed and sent away to the maker, and have a ring fitted which will keep the clapper in suspension and therefore save the valve.

RAYMOND J. ROE.

Cleaning Brine Tank Coils

THERE IS, in my plant, one 35-T. and one 50-T. brine tank for the manufacture of ice. The ammonia coils in these tanks have received no attention whatsoever for the last six or eight years, and I am of the opinion that they are thoroughly choked up with scale, sediment and oil, as we are now considerably below production. This winter I intend to overhaul the system thoroughly, and was considering the idea of circulating a 20 per cent solution of caustic soda in the coils for one or two hours, and after drawing it off circulating fresh water through them, then blowing the coils out separately with steam, and afterwards with compressed air.

I would like to have your opinion as to the proper method of procedure in this case. Years ago we used steam altogether for ordinary cases; and afterwards went to compressed air to get away from expansion created by the steam. OPERATOR.

A. We regret that you do not tell us how the expansion coils of the two freezing tanks are connected. The length of time, 6 or 8 yr., during which the coils have had no attention, is sufficient to warrant their being most thoroughly cleaned. The method to be pursued must perforce depend somewhat on the arrangement of the coils. For cleaning, the most advantageous arrangement is that in which the connections to the bottoms of the coils pass out through the walls of the tank horizontally in such a way as not to form pockets. Where this is the case, the coils can be drained more thoroughly when the manifolds or headers are disconnected. Where the coils "return" and connect to headers at the top of the tank the problem becomes more difficult and requires more careful work.

In seeking to dislodge foreign matter in expansion coils it should be continuously borne in mind that the principal fouling material is oil, ice machine oil, which in its normal condition has a low enough viscosity, but which in the course of time becomes contaminated by scale, microscopic particles of iron from the compressor pistons and cylinders, and rubber graphite and other substances from the rod packing, all tending to make the resulting fluid more viscous and proportionately more difficult to remove from the system. Solution in a lighter mineral oil such as kerosene or gasoline would facilitate its removal, but the use of these oils would be attended by prohibitive danger unless the greatest care were exercised at all times, to guard against explo-

sions by flame ignition of explosive mixtures of these oils with air, during the cleaning operation, or by pressure, if any residual oil is subjected to an air-test pressure after the cleaning.

Fortunately, viscosity can also be reduced by the application of heat and this agent lends itself most readily to the cleaning of expansion coils. Any method which will insure heating the oil a reasonable amount will be found effective. Blowing steam into coils immersed in cold brine will not be productive of effective results unless continued for a sufficient length of time to heat the brine and in such a way as to permit the steam to blow through the coils with sufficient velocity to entrain the oil. Needless to say, such a velocity at the discharge end of a long expansion coil can not be realized until the coils are thoroughly heated.

It is not believed that the use of chemical solvents would prove sufficiently effective to warrant the introduction of an additional "foreign" substance into the ammonia system.

The most effective method for disposing of oil in expansion coils, whether employed in ice-freezing tanks, brine tanks or cold storage rooms is to blow them out with the highest pressure steam available, continuing the blowing process, preferably on each coil separately, until no oil appears in the discharged steam. The coils should then, while kept warm by steam introduced into the brine tank, with the covers on, be blown out with compressed air. It should be remembered that not only can the moisture absorbing capacity of the air be increased by keeping it as warm as possible, but also that it is greater in inverse ratio to its absolute humidity. Cold, out-door winter air, while having a high relative humidity not uncommonly reaching the saturation point or 100 per cent, has, nevertheless, a low water vapor content or absolute humidity and accordingly is capable of absorbing a relatively large quantity of water vapor when its temperature is raised.

For example, zero degree saturated air contains 0.068 lb. of water vapor per 1000 cu. ft. while 1000 cu. ft. of air in a saturated condition at 100 deg. F. contains 2.823 lb. of water. It is therefore apparent that the most advantageous time to dry out expansion coils with air is when its absolute humidity has been lowered on account of low temperatures, natural or artificial, to which it has been submitted, after which its moisture-absorbing capacity should be not only made as high as possible but also kept as high as possible by heating it and keeping it hot until it is finally discharged with the moisture it has absorbed from the coils. It is scarcely necessary to suggest that taking the suction of the air compressor from a low temperature cold storage room would be as advantageous as from the outside, provided it is as cold.

From the foregoing it will be apparent that the principal operation of the cleaning process lies in heating the coils. Whether or not this will lead to trouble because of the resulting expansion should be determined for each individual job. Unless there are soft rubber packed joints so disadvantageously located within the tank as to be entirely inaccessible for tightening in case the rubber is softened by the high temperature, it is believed the advantages to be gained from making a thorough job of the cleaning operation will readily outweigh any trouble occasioned by the heat, provided its effects are located and remedied before the system is put into operation. Oil is an effective insulator and must not be tolerated where, as in the case of expansion coils and condensers, the efficiency of the whole system depends on making and keeping the coefficient of heat transmission as high as possible. F. E. MATTHEWS.

Massachusetts Second-Class Engineers' Examination Questions

WHAT WOULD you do if you were running a large condensing engine and you lost the vacuum?

2. What changes would you have to make in the open heater if you wanted to raise the back pressure in the heating system up to 2 lb?

3. Describe the induction heater?

4. What is the valve and pipe for on the drop leg of a blowoff tank?

5. Why does the side shaft revolve once to two revolutions of the crank shaft on a Putnam engine?

6. How do you reverse the Putnam engine?

7. Name the different ways for a single riveted lap joint to fail.

8. How can you change the compression on one end of the Fitchburg engine?

9. Which way does the governor rod move as the weights fly out, on the Browne engine?

10. If the old slide valve had been lost, how would you know how much lap to use on the new valve?

ANSWERS

TRY TO get it back by overcoming the trouble, cool the condenser, start the air pump going. If the condenser were out of commission raise the boiler pressure if possible.

2. It is not necessary to make any change in the heater, but you will have to change the weight on the back pressure valve.

3. In this heater, all of the exhaust steam does not enter, but only enough to heat the water. There is a vent back into the exhaust line.

4. To prevent the water from siphoning out of the tank.

5. If the side shaft revolved at the same speed as the crank shaft the cam would open the valve twice per revolution.

6. Reverse the bevel gear on the shaft.

7. By crushing of the plate in front of the rivet, tearing of the plate between the rivet holes and by shearing the rivet.

8. The exhaust valves are on the same rod, and the compression could be changed by shimming between valve and collar on the valve rod.

9. It moves down.

10. Lap is equal to one-half the eccentricity minus the width of the steam port. L. N. W.

SENATOR KENYON recently introduced a bill in the United States Senate, the purpose of which is to provide for the settlement of disputes between employers and employees in the coal-mining industry; to establish a board for the adjustment of such disputes; to stabilize conditions of production; and for other purposes.

WHEN YOU make a report or suggestion to the boss, have it clean-cut, brief and fully thought out.

POWER PLANT ENGINEERING

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Predicting Boiler Efficiency

We have all marveled at the accuracy with which artillerymen handle their big guns so that they never miss the target more than a few feet even though it may be several miles distant. Yet there is nothing particularly marvelous about this; science has given us the law of falling bodies, numerous experiments have taught what may be expected from various quantities of different explosives and the effects of wind. The artilleryman places his gun in a certain position which has been calculated for him and if he does not hit his target he is surprised and looks for errors in adjustments, just as a mathematician looks for an error in calculation if his results do not check or as a bookkeeper looks for a mistake when his books do not balance.

When dealing with exact sciences such as mathematics, physics, chemistry, there seems to be but one excuse for not being able to predict the results obtainable and that is the lack of experimental data covering all conditions affecting the results. In the power plant we use these exact sciences almost entirely; we know what water pressure to expect from a tank of a given elevation, the amount of heat that is radiated from pipes of various sizes and temperatures, we can calculate the heat transmitted from one substance to another through a metal wall, we can predict generator, motor, transformer and transmission line losses and many other results when the influencing conditions are known.

There are, however, some results which depend upon so many variables that we consider an actual test the only means for estimating the results that are obtainable. Probably the most noteworthy example of this is the efficiency which can be expected from boilers.

Logically a definite amount of coal of a known heat value burned in one hour should produce a definite amount of steam. Practically, however, a number of influencing conditions enter which affect the results to such an extent that an actual test is resorted to when it is desired to know the efficiency obtainable under certain conditions. The percentage of ash and its behavior at the furnace temperature are two of these conditions; the volatile combustible content of the coal and the furnace volume are others; air leaks in the setting, scale and soot on tubes, rate of combustion of coal and rate of evaporation, all have influences on boiler efficiency difficult even to estimate roughly.

Knowing, as every engineer does, the varying conditions that surround boiler operation, there will be considerable doubt as to the practicability and accuracy of the method of estimating the efficiency of boilers which is described in this issue by Hugh R. Carr.

Nevertheless the progressive engineer is not of a prejudiced mind and will give this method a fair trial, checking it against actual test results, thus determining its limitations and we have no doubt will find, as has Mr. Carr, that it will in many cases save not only time but considerable expense.

Experimental work has been carried far enough with boiler operation that the engineer can begin to recognize it as an exact science and, like the gunner, will, as further investigations are carried on, be in position to predict with a certainty the effects upon efficiency of any variation of conditions, and the attempt by Mr. Carr along this line is one of the pioneer steps worthy of careful consideration.

Battery Charging Equipment

While the care and maintenance of storage batteries usually requires more or less expert attention, the most important feature about any installation is the provision of proper charging apparatus. Given the correct charging equipment and a reasonable amount of attention on the part of the operator, the life and safety of the batteries will be assured. Now, charging equipment may be obtained in various forms and for various capacities and voltages, and to the inexperienced man the selection of the proper apparatus for his particular battery installation is quite a problem. Of course, where cost is a secondary consideration, he can consult manufacturers of high grade equipment and purchase from them all the necessary apparatus and protective devices, and rest assured the equipment so obtained satisfies all the requirements. Cost, however, is not a negligible item in most plants and the average engineer will usually attempt to work out the solution to his charging problem himself. In order to do this, a clear insight into what is really necessary and what is desirable to justify the expenditure of an additional first cost is essential.

In the pages of the current issue, H. M. Phillips, in an article entitled "Equipment for Battery Charging," explains in detail the various factors which govern the selection of rheostats for battery charging. This is one of a series of articles by Mr. Phillips dealing with battery charging which will be published in an endeavor to give the readers a clear insight into this particular phase of engineering.

Off Duty

Most of us who have had work to do around the boiler room have probably performed, at one time or another, the simple experiment of making coal gas. This, you will recall, consisted of filling the bowl of an ordinary clay pipe with a piece of soft coal, covering the top over with a piece of moist clay, and heating it in a moderate fire. In a few moments you found gas issuing from the pipestem, which, when lighted with a match, burned with a smoky flame. If you have not already tried this simple stunt, keep it in mind and try it out the next time you find yourself Off Duty. While we won't guarantee the pipe to be the most efficient generator of gas ever made, we assure you that among other things, it will furnish much food for thought. For one thing, after all of the gas has been driven off, you will find upon opening up the bowl that it contains instead of the coal you put in it, a piece of dry porous coke.

The distillation of coal in this manner has, thus, produced two, more or less, valuable commodities: first, a gas which might be used either for illumination or heating; and second, coke, which has a number of important commercial applications.

If you are uncommonly observant, however, and examine your improvised gas generator rather closely, you will find in the pipestem about midway between the bowl and the end, a bit of dirty, moist substance. What is it? "Dirt," you say, and start to clean it out, and perhaps that's what you had better do, for unless you happen to be a chemist it is of little value to you.

But that little bit of ill-smelling, dirty substance possesses a wondrous charm and to those who know the secret spring which will open up its doors, it will unfold marvels, in comparison to which the magic of even the Arabian Nights pales into insignificance. It contains the stored-up treasures of eons; the sunshine of the carboniferous period is locked up within its black walls—within the walls of this sticky, smelly mass we call coal tar.

Milady, when she scents her handkerchief with the sweet scented perfume of the lilac, little realizes that this fragrant liquid is made from that same dirty coal tar.

When afflicted with a headache, we take a couple of snow-white aspirin tablets to alleviate the pain, we, are, perhaps, not to be criticized for not associating the aspirin with a bit of tarry matter we find in a pipestem. When we cut ourselves and anoint the wound with a dilute solution of carbolic acid, we little realize that that germ-killing fluid was made from dirty, black coal tar. Carbolic acid, chemically known as Phenol, was one of the first of the coal tar antiseptics to be employed, and Dr. Lister, who first employed it in 1860, is called "the father of antiseptic surgery." But during the war, there were introduced even more remarkable antiseptics. Two of these, Proflavine and Acriflavine, will kill the germs producing ordinary abscesses when in solution as dilute as one part of Flavine to 200,000 parts of water, but at the same time the antiseptic does not interfere with the repair action of the white blood corpuscles; yet its action is claimed to be 800 times as strong as carbolic acid. Like the others, the Flavines are also made from coal tar.

Cocaine, the natural product, is extremely valuable to the doctors as a local anesthetic, but is often poisonous. The coal tar chemist after carefully studying this product found out which atoms were the ones that were valuable in producing local anesthesia and which were the poisonous ones, detrimental to the human body. Knowing this, he was able to improve upon nature and today he makes Novocane and Procane out of coal tar. Procane is better than cocaine, because it is equally good, yet possesses none of the poisonous characteristics.

But we must stop; we can but touch upon this wonderful subject here. We have said nothing of dyes, of the thousands of beautiful shades with which we color our fabrics, of the high explosives in comparison to which gunpowder is but a plaything, and of the coal tar poison gases used in the war. We might write books about each of these, each one as fascinating as a fairy tale. In the end, however, all we could say is, that they are all made of that dirty, nasty, ill-smelling residue we found in our pipestem, called coal tar.

Power Plant Slogans

Keep and Analyze Operating Records in Every Power Plant.
Develop Water Power Sites.
Promote Health and Safety in Power Plants.
Handle Coal and Ashes Mechanically.
Employ Engineers for Engineering Work.

The R-K Step Compensated Fan Engine Regulator

THE Ruggles-Klingemann Mfg. Co. has recently developed a novel arrangement for step compensating a fan engine regulator so that the motor plunger will have definite cutoff points. While the method of compensating of the plunger travel of damper or fan engine regulators is old, the cutoff points of such regulators are not fixed. The improvement now made, provides definite cutoff points at which the motor plunger must come to rest before proceeding to the next stage of travel.

It consists of a regulator which can be so adjusted to load variations as to establish a series of damper or

THE R-K STEP COMPENSATED REGULATOR

fan engine settings in which the air supply to the furnace will correspond with definite boiler ratings, at each cutoff point or step, which will be in exact relation to the load requirements.

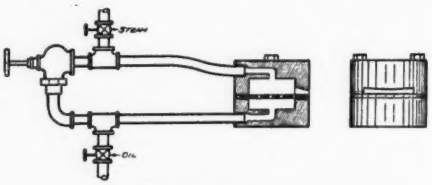
In the construction of this regulator, a compensating wedge having steps is connected to and moves with the motor plunger. An arm having a roll is in contact with the step side of the compensating wedge, and through suitable linkage operates to close the pilot valve at each step on the wedge. At the same time the pilot valve is closed, a counteracting force is applied to the scale beam, through the medium of a spring, which means that a new pressure value must be set up before the valve can be again opened and the motor moved to the next succeeding stage of travel.

With this regulator, the pressure variation between compensating stages may be varied and the total variation between minimum and maximum stages of travel may be any range from 1 to 10 lb. In plants where the load is uniform, the regulator may be adjusted to operate on a comparatively small variation between its operating limits. In some cases, a 3-lb. range can be used to advantage; but under conditions of a fluctuating load, a wider operating range must be provided for, and the regulator may be adjusted for a 10-lb. variation between these limits if required.

The Ideal Oil Burner

THE ever-increasing demand for greater economy in the use of oil fuels has led to the development of many devices for the efficient burning of such fuels in recent years. One of the latest is the Ideal oil burner, manufactured by The Ideal Oil Burner Co. of Port Arthur, Texas.

In the design of this burner the builders have endeavored to produce a simple and fool-proof contrivance which will enable the fireman to improve his efficiency and methods of operation. The construction,



IDEAL OIL BURNER

as shown by the accompanying illustration, is exceedingly simple, as there are but three parts: the top casing which contains the steam chamber, the bottom casing, which contains the oil chamber, and the vaporizing plate, which separates these two chambers and in addition makes the steam chamber serve as an internal mixing chamber for the steam (or compressed air) and the fuel oil. It is adapted to burn oil fuels of every grade, and in practice even still bottoms as low as 6 deg. Baume in gravity, have been vaporized successfully without any excess carbonization in the burner, or decrease in boiler output.

Because of the flat flame, the internal mixing and the steam atomizing feature, this burner is well adapted for use under widely varying conditions. One unit is capable of handling upwards of 500 boiler horsepower.

It is simple in construction and can be removed from the line, cleaned, and reinstalled, within 5 to 10 min. time.

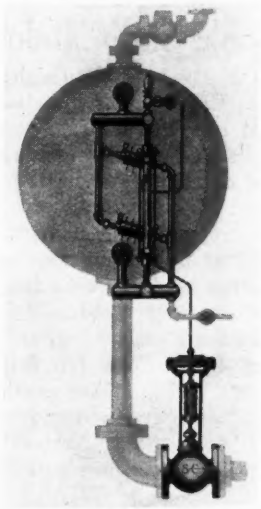
Receiver Drainage Control

THE "S-C" Regulator Manufacturing Co. has recently placed on the market what is known as a receiver drainage control, an apparatus which accomplishes the same results as a nonreturn trap or a pump in emptying a receiver tank.

The apparatus consists essentially of a tube or pipe which is in communication with the receiving tank: one end connects to the steam and the other to the water space, thus the water level in the tube is the same as

in the tank. The temperature of the water in the tube, however, will be less than in the tank, due to radiation. About this pipe, at the point at which the level is desired to be maintained is constructed a shell which is connected by means of a small tube with a diaphragm operated valve controlling the discharge from the tank. Any variation of pressure in this shell will then be communicated to the diaphragm and will operate to open or close this valve.

When water is low in the tank that portion of the tube covered by the cylindrical shell will contain steam,



CONDENSATE RECEIVER DRAINAGE CONTROL

the water in this shell will be heated and its pressure will be increased. This pressure acts on top of the main discharge valve diaphragm and closes the valve, allowing water to accumulate in the tank.

As the level rises, relatively cool water occupies the tube and abstracts heat from the liquid in the outer shell. This radiation of heat, assisted by radiating fins on the shell, reduces the temperature and consequently the pressure of the water in the shell. This reduces the pressure on the valve diaphragm and allows a spring to open the valve to discharge the contents of the tank.

Another similar apparatus is located at a higher level to actuate a whistle valve to give an alarm when the water in the tank reaches any prearranged maximum level.

The gage glass is provided to show at a glance the position of the water level. It is thus a telltale on the operation of the apparatus.

The absence of all moving parts excepting the valve stem is noteworthy, as it makes for increased reliability of operation and increased life.

Indoor Oil Circuit Breakers of Moderate Capacity

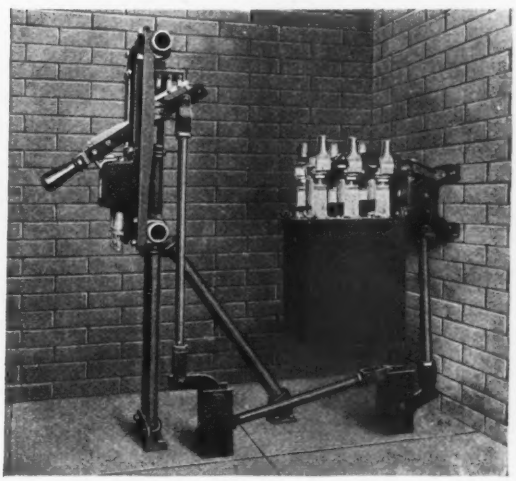
A NEW LINE of oil circuit breakers is being put on the market by the Westinghouse Electric & Manufacturing Co. These are moderate capacity indoor breakers, known as Type "F-11," manually operated, non-automatic and automatic, with one, two or three trip coils. A 200-amp. 4500-v. and 400-amp. 2500-v. breaker is made in two and three poles, single and double throw.

The breaker unit may be mounted on the panel for direct control or on wall for remote control without change, or on pipe for remote control by the addition of a simple mounting bracket. The same operating mechanism is used for direct panel mounting or remote control breakers; it is only necessary to add two bell cranks to the panel mounting breaker to adapt it to remote control.

To the non-automatic operating mechanisms may be added 5-amp. transformer trip coils, series trip coils up to 200 amp. 5-amp. transformer trip or series trip with inverse time element dashpots, under voltage release mechanism with or without resistance, shunt trip coils for alternating or direct current direct trip attachments, bell alarm contacts and a 2 P. D. T. signal switch, thus adapting it to all kinds of protective schemes, with or without relays and all signalling arrangements.

The breaker opens by gravity, assisted by tension springs, and it is equipped with bumpers to absorb all shocks of opening. The open position is maintained by gravity. The tanks are removable without the necessity of disturbing operating mechanism or contacts and there is ample air space at tank top to allow for gas expansion. Poles are isolated in individual cells by insulated tank liners and partitions.

The stationary contacts are fitted with self-alining fingers. These fingers have flared surfaces that guide the moving contact during the closing stroke. The most important function of these flared surfaces, however,



NON-AUTOMATIC OIL CIRCUIT BREAKERS: CAN BE MADE AUTOMATIC

is to take the arc incident to opening heavy short circuits. This arc is drawn between the flared surfaces and the top edge of the moving contact, leaving the flat surfaces that are in contact when the breaker is completely closed, smooth and clean to carry normal current of the breaker. The contact pressure of the fingers is very great.

News Notes

SIL-O-CEL AND ALL CELITE products formerly distributed through Nightingale & Childs, are now being handled through the Celite Products Co.'s own district office at 79 Milk street, Boston, Mass.

THE GENERAL SALES DEPARTMENT and New York branch office of the Ames Iron Works was moved to the Liggett Building at 41 East 42nd St., New York City, on March 1.

J. C. LONG, for the past 15 yr. chief plant engineer of the Boston Woven Hose & Rubber Co., has resigned his position and has opened offices in Old South Bldg., Boston, Mass., as power plant consulting and betterment engineer.

THE DENVER GAS AND ELECTRIC COMPANY will spend $80,000 for the remodeling of the East Side substation, and then christen it "Barker Sub," in memory of William J. Barker, late vice-president and general manager.

ROBERT M. GATES has recently become associated with The Superheater Co., with his headquarters at the general offices of the company, New York City. Mr. Gates was formerly a partner of the Herron Gates Co., of Cleveland, Ohio, handling power plant equipment, prior to his association with the Lakewood Engineering Co.

THE U. S. CIRCUIT COURT of Appeals, Second Circuit, New York, rendered an opinion on Feb. 14, 1922, affirming a decision previously handed down by the Federal Court at Buffalo, N. Y., that sustained a patent owned by The Permutit Co., covering zeolite water softeners. According to this decision, exclusive rights to manufacture zeolite water softeners are granted to this company.

THE DIAMOND soot blower business has been purchased by new interests in the form of the Diamond Power Specialty Corporation, of Detroit, Mich., a new company which has taken over the business and plant of the Diamond Power Specialty Co., Co-partnership, the members of which are retiring from the soot blower business in the Western Hemisphere. Norman L. Snow, president and treasurer of the new company, has resigned his position as vice-president and active head of the Terry Steam Turbine Co. of Hartford, Conn., with whom he has been connected for the past 13 yr.

ACQUIREMENT OF the plant and interests of the Pelton Water Wheel Co. of San Francisco and New York by the William Cramp & Sons Ship & Engine Building Co. of Philadelphia has recently been announced.

The Pelton Water Wheel Co. retains its old corporate name and no material change in policy is contemplated, but new officers have been chosen, as follows: H. B. Taylor (vice-president of The William Cramp & Sons Ship & Engine Building Co.), president; Ely C. Hutchinson (formerly chief engineer of The Pelton Water Wheel Co.), vice-president and general manager; William M. Moody, second vice-president.

The Pelton Co. was organized in 1887 to take over the manufacture of the Pelton impulse-wheel. The Cramp Co. handles its hydraulic turbine construction through its I. P. Morris Department. This concern was originally established as a separate company in 1828 and commenced the construction of hydraulic turbines in 1851. Control of the company was acquired by the Cramps in 1891. The I. P. Morris Department has built some of the largest reaction turbines in the world.

The consolidation of these two concerns, each with its remarkable record of achievement, the Pelton Water Wheel Co. in impulse turbines and high-head reaction turbines, and the Cramp Co. in large reaction turbines, mainly for relative low heads, will enable the combined organization to cover the entire field of hydraulic prime-mover construction.

Books and Catalogs

COAL MANUAL. By I. R. Wadleigh; size 4½ by 6; cloth, 184 pages; Cincinnati, Ohio, 1921.

The apparent need of accurate elementary knowledge, on the part of salesmen and users of coal, its origin, structure, chemistry and uses, has brought forth this little manual which presents this information in a non-technical and practical manner.

The subject is taken up from various different angles under such general heads as coal and its relation to civilization, various uses, classification, coal fields of the world, production, analysis, specifications for purchase, sampling, instructions for firing, methods of using, by-products, coke, stoker combustion, storage, spontaneous combustion and other allied topics.

The material has been well arranged and by the use of numerous captions and a complete index any desired information is made readily available.

EDUCATION AND FUEL CONSERVATION is the title of a leaflet just published by the Hays School of Combustion.

A FOLDER entitled "Simplicity Fuses" has just been issued by the Cote Bros. Mfg. Corporation, Chicago, describing the new refillable fuse of that name.

THE NEW Walworth "Kewanee" union, of forged steel and forged manganese bronze, is the subject of a circular from Walworth Manufacturing Co., Boston, Mass.

THE WESTINGHOUSE ELECTRIC & MFG. CO. has issued Folder No. 4482, entitled "Popular Motor Mechanics," in which are described and illustrated many practical uses for small motors. The publication is written and illustrated in such a manner that any person will readily understand the uses for and the methods of operation of the motors.

A NEW BULLETIN on the Quigley Fuel Systems, comprising methods of preparing, transporting, and burning of pulverized fuels, has just been published by the Hardinge Co., New York City. This bulletin is known as No. 12 and lays emphasis upon the methods employed properly to prepare and burn the powdered coal. Aside from complete plant layouts, what is termed a "Unit Milling Plant" is described. The system, which is a new development, comprises a method of pulverizing and transporting the coal to one or more furnaces in the same locality, at the same time securing positive regulation and continuous operation over extended periods. The cost of this unit is but a fraction of that of the larger systems where the coal must be transported several hundred feet to a number of furnaces.